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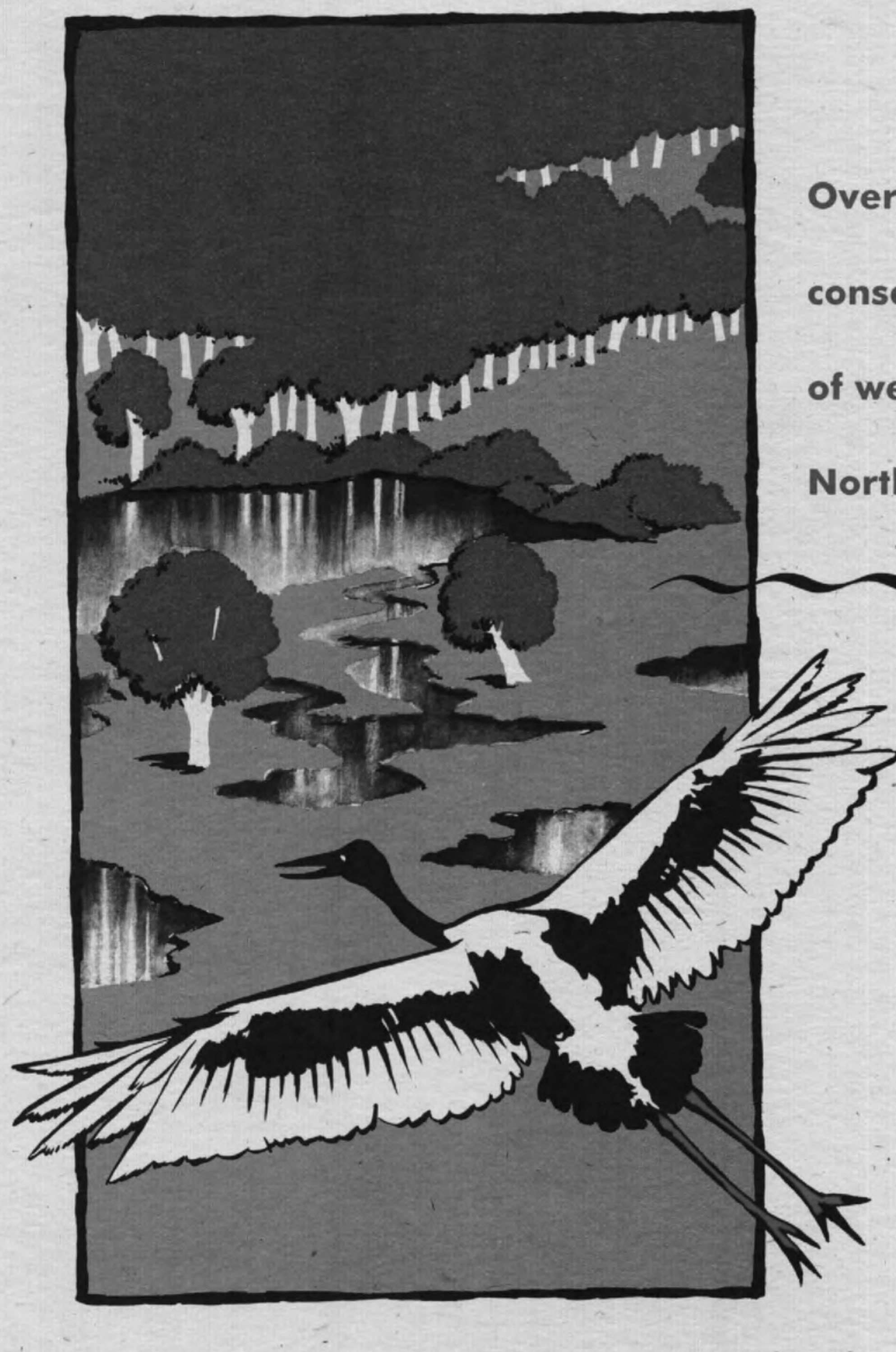

Overview of the conservation status of wetlands of the Northern Territory

Michael J Storrs
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This overview was undertaken as a consultancy project on behalf of the Parks and Wildlife Commission of the Northern Territory. The content is in line with the terms of reference of the consultancy and the report is published with the permission of the Commission. The views expressed represent those of the authors and not necessarily those of the Commission.

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Summary

1 At the request of the Northern Territory Parks and Wildlife Commission an overview of the conservation status of wetlands in the Northern Territory (NT) is presented as a background resource and discussion paper for the development of a wetlands policy. The conservation value of wetlands and the threats that they face have been described within a framework of sustainable utilisation of resources and maintenance of biological diversity. Thus, an information base for conservation managers has been summarised. Strategic directions have been indicated, but it is stressed that a strategy for the proposed wetland policy has not been presented. A process of intra-governmental and community consultation is required to produce such a strategy.

2 The information contained within this report is presented on a biogeographical basis at two different levels. For general purposes three broad regions of the NT were considered – northern, central and southern. For specific planning and management purposes the Interim Biogeographical Regions of Australia (IBRA) have been used. Datasets pertaining to wetlands in the NT have been identified and described in a comprehensive Appendix. Information on nature reservation, wetland resources, land uses and dominant threats to wetlands is also presented in Appendixes with summary points made in the text. A comprehensive bibliography is attached.

3 Wetland definition and classification within the NT require further attention. Commonly used definitions and classifications are not generally useful within the NT context. A simplified classification was used in this overview, but its limitations were recognised. The categories of wetlands identified were – coastal salt marshes, mangrove swamps, freshwater lakes and swamps, floodplains, freshwater ponds, and seasonal and intermittent saline lakes. It is stressed that classification should be used to promote unity of purpose and not serve as a dampener to further innovation and management.

4 Current inventory information for NT wetlands is deficient. Unless this situation is greatly improved wetlands management and conservation will, in part, need to rely on an uneven information base. Inventory information is particularly poor in the central and southern regions of the NT. The further development of a meta-database to hold records of all databases pertaining to wetlands is strongly supported. A thorough synthesis of the many databases identified in this overview would greatly assist resource planners and researchers.

5 Much of the information used for general descriptions of the wetland habitats of the NT is readily available in published reports. It need not be repeated here. It is pertinent, however to point out that these habitats are an invaluable component of our national biological diversity and require further strategic management. The monsoonally influenced wetlands across the northern coastal zone are well studied and undoubtedly of high conservation value given the diversity of plants, animals and habitats. However, those of the semi-arid and arid zones are less well known, but given the nature of the environment are also undoubtedly highly valuable.

6 The conservation status of individual wetlands of the NT has not been assessed and indicators of ecological integrity have not been developed. Further assessment, monitoring and audit of the conservation status of wetland habitats and ecosystems is needed. For this to be successful baseline information on the ecological character of the wetlands is required and should be coupled to effective monitoring programs. Monitoring programs should be well designed and be able to answer discrete objectives within realistic timeframes.

7 The nature reserve system is one of the most valuable assets for the maintenance and management of genetic, species, community and landscape diversity, as well as key ecological functions and processes. The existing network of reserves does not offer comprehensive protection of the faunal or floristic diversity of wetlands. Further assessment of the need for reserves is required along with the development of off-reserve conservation arrangements. Wetlands are well represented in reserves in the northern region, but this is not the case in the central and southern regions.

8 Existing or emerging threats to wetlands include: plant and animal pest species; fire and burning regimes; overgrazing; pollution and contamination; tourism and recreational activities; and water regime and physical modification. These do not affect all wetlands, but there are few wetlands that have not undergone some level of adverse change in ecological character.

9 A list of weed species in NT wetlands is presented. Many plant species have caused problems and major control programs have been successfully implemented for some of them. However, very little is actually known about the ecological change wrought by these species. The major weed species are *Acacia nilotica* (prickly acacia), *Brachiaria mutica* (paragrass), *Cenchrus ciliaris* (buffel grass), *Eichhornia crassipes* (water hyacinth), *Mimosa pigra* (mimosa), *Parkinsonia aculeata* (parkinsonia), *Prosopsis limensis* (mesquite), *Salvinia molesta* (salvinia) and *Tamarix aphylla* (Athel pine).

10 Paragrass is a pasture species that has spread from grazing land to conservation reserves. Two less widely spread species, *Echinochloa polystachya* (aleman grass) and *Hymenachne amplexicaulis* (olive hymenachne), similarly threaten to invade nature reserves. These species form monocultures and adversely affect the structure and functions of the wetlands concerned. In many cases these species are still being deliberately introduced without a thorough analysis of the risks that they pose.

11 Mimosa is considered to be a major menace to the floodplains of the northern region of the NT. Management emphasis has centred on control techniques including the release of biological control agents. Integrated control programs incorporating biological control along with the use of herbicides, mechanical removal, burning and revegetation are increasingly being used. A 'search and destroy' policy has been successful in Kakadu National Park, but elsewhere expensive chemical control programs are still being undertaken. Post-control rehabilitation deserves a lot more attention.

12 Salvinia is a widespread weed species but, as with many other species, its effect on the wetlands has been little studied. Biological control can be effective, but in some instances must be integrated with chemical control.

13 The main feral animal pest in the northern coastal wetlands was formerly *Bubalus bubalis* (Asian water buffalo), which was responsible for the widescale destruction of native vegetation. Large herds now only exist in parts of Arnhem Land following a successful eradication program directed towards protecting the domestic livestock herd. The rapid removal of buffalo has resulted in further large scale change with both native and alien plant species overgrowing stream and billabong banks and spreading across the floodplains.

14 Other animal pest species include *Camelus dromedarius* (camel), *Equus caballus* (horse), *Equus asinus* (donkey), *Oryctolagus cuniculus* (rabbit), *Sus scrofa* (pig), *Bufo marinus* (cane toad) and exotic fish. Pigs have caused widescale damage, but control is often difficult. Cane toads pose an ever increasing threat, although evidence to support the extent of the threat is not conclusive.

15 The incidence of fire on the coastal floodplains has increased since the removal of large numbers of buffaloes. Vast areas of the central and southern regions of the NT are burned every year including many intermittent or episodic wetlands. Little direct analysis of the effect of fire on the wetlands has occurred.

16 Soil erosion following overgrazing of wetlands is a major issue in the central and southern regions of the NT. Again, however, very little is known about the actual effect of such changes on the wetlands. Pastoralism is a major land use and is generally considered to have been detrimental to the ecological character of many wetlands.

17 Tourism is an increasingly important industry with localised impacts due to high visitation numbers expected to increase. Recreational fishing for barramundi has already seen the introduction of regulatory measures. Other fish may be subject to similar pressure. Waterfowl hunting can also result in lead poisoning of waterfowl from ingested lead pellets.

18 Land uses as diverse as mining, tourism, urbanisation and agriculture all bring a threat of water pollution. Mining has attracted a lot of attention and is now more often subject to strict regulation. Less is known about the effect of agricultural chemicals on wetlands. Salinisation of the coastal wetlands is an increasing problem and could be exacerbated by climate change processes.

19 As many NT wetlands exhibit both physical and biological linkages it is extremely difficult to separate them into discrete management units. The physical linkages are best illustrated by the seasonal freshwater flooding of the coastal floodplains and mangroves. Biological linkages are shown by highly mobile or migratory species such as waterbirds and fishes. Successful conservation management and abatement of threats needs to take these linkages into account. Even large reserves, such as Kakadu National Park, are affected by activities that occur far from the park itself. For effective conservation a suite of interconnected wetland sites may be needed. In some instances, conservation covenants or management agreements may have to be placed across complexes of wetlands regardless of land tenure.

20 The NT has adopted a multiple use policy for its wetlands. This policy attempts to encourage different land uses and to provide a balance with conservation objectives. Current land uses are not generally intensive, but even the extensive grazing industry has resulted in widespread degradation of valuable wetland habitat. Conservation can be compatible with multiple land use under a sustainable development ethic, but conflicts can also occur. Holistic approaches and consultation, such as that underway in the lower Mary River, should be further developed and supported by local initiatives.

21 Given that many conservation issues in wetlands need to be immediately addressed, management actions have to rely on currently available information. However, every step must be taken to improve the information base. Key actions for wetland conservation include: development of a sound inventory of wetlands; development of regional land use and consultative processes that address both local and global scale issues; extension of the reserve system based on a systematic assessment of conservation needs across biogeographical regions; improved off-reserve conservation measures; risk analysis and effective control of pest species; cooperative management structures for grazing; protection of critical habitats through truly multi-sectoral approaches; and continued attention to public awareness and education.

22 Some of the above actions may need to be accompanied by changes to legislative and administrative structures to reflect the multi-sectoral nature of wetland functions and uses. It may be profitable to employ a consultative approach to a review of the interaction between legislation and the multi-sectoral values placed on wetlands.

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Data used in figures 5–8 of this report was supplied by the following institutions: Australian National Herbarium, National Herbarium of NSW, Northern Territory Herbarium, Queensland Herbarium, Botanic Gardens of Adelaide and State Herbarium, Tasmanian Herbarium, National Herbarium of Victoria and Western Australian Herbarium.

1 Introduction

The ecological character of wetlands of the Northern Territory (NT) has been described in a general sense and the major threats or management problems identified in a number of publications (eg Finlayson et al 1988, 1991, Finlayson & von Oertzen 1993, Fleming 1993, Jaensch 1994). These reviews and reports on specific localities (see, for example, papers in Finlayson 1995, Jonauskas 1996) have also identified major gaps in our knowledge of basic ecological processes and threats to wetlands and, in the more isolated areas, even the character and extent of wetlands. Despite a general level of knowledge the information base is not uniform. Whilst reasonable data/information exists for some wetlands and/or threats to wetlands, a comprehensive inventory of all wetlands in the NT is not available (see Appendixes 1–4), even at the most basic level (encompassing, for example, information on physical and ecological features, values and benefits, land tenure and uses, threats and disturbances, and monitoring and restoration).

The information collected through wetland inventories is regarded as a necessary prerequisite for conservation and management at a holistic level (see papers in Finlayson & van der Valk 1995). A strategically developed wetland inventory (or inventories) should provide managers and/or policy makers with the information base that they require not only to manage individual wetlands or threats, but to also place the conservation value of wetlands within the context of broadscale (catchment, regional or even national) land use and sustainable development priorities. It is important therefore, that the information contained within the inventory meets the needs of the managers and/or policy makers. Information categories often used in wetland inventories are provided in Scott (1993) and placed in a management context by Finlayson (1996).

Management of wetlands in the Northern Territory is governed by the broad directions established by the *Conservation Strategy for the Northern Territory* (Northern Territory Government 1994) which has four major goals:

- the conservation of existing biological diversity;
- the conservation of natural and cultural heritage;
- the sustainable utilisation of natural resources; and
- the maintenance of a clean, healthy environment

With these general directions in mind, this overview summarises the extent of information on NT wetlands (see Appendixes) and presents this as the first phase of an inventory that takes into account the biogeographical zonation of the NT. The inventory is then used as a basis to:

- characterise the wetlands;
- assess the conservation status of wetlands;
- consider ecological linkages between wetland types;
- identify dominant uses of wetlands and assess their sustainability; and
- identify and propose responses to adverse situations or processes affecting wetlands

The overview is designed as a background and discussion paper for the development of a wetlands conservation strategy for the NT and was undertaken as a consultancy project on behalf of the Parks and Wildlife Commission of the Northern Territory. Noting that the broad strategic directions for this strategy are contained within the Conservation Strategy for the NT, further broadscale directions have not been recommended. Rather, the conservation value of wetlands and the threats that they face have been identified and described within a framework of sustainable utilisation of resources and maintenance of biological diversity. Possible responses to these threats and factors that require consideration in setting management goals and objectives are then presented and discussed.

Thus, we have compiled an information base for conservation managers and indicated strategic directions that are needed if the goals of the Conservation Strategy for the NT are to be achieved. We have not presented a strategy for wetland management in the NT as this can only be effective if achieved through a process of intra-governmental and community consultation. The philosophical framework for the discussion is based on the concept of sustainable utilisation of natural resources which encompasses maintenance of biological diversity and, where applicable, the multiple use of wetlands (see Fulton 1995) and their values and benefits to society. In other words, the conservation and maintenance of biological diversity are encapsulated within a framework of sustainable utilisation; conservation is not treated as a process that is separate from land use.

2 Geographic setting

As a prelude to the more focussed information outlined above, the geographic and particularly the climatic setting of the NT is described. The NT lies between latitudes 11°S and 26°S (figure 1) and encompasses a large proportion of tropical Australia. Distribution of wetlands reflect both the climate and general landform/drainage pattern with more permanent and/or seasonal wetlands in the north giving way to more intermittent and/or episodic wetlands in the south.

2.1 Landforms

The 1 347 x 10^6 km^2 area of the NT is divided into three broad landforms (figure 2a). In general, the tropical northern zone contains large rivers that provide sediment and floodwater to wide coastal plains with permanent and seasonal wetlands. The central semi-arid zone of uncoordinated drainage contains seasonal and intermittent wetlands while the southern lowland zone of coordinated drainage contains intermittent and episodic wetlands.

The northern zone includes plateaux with few wetlands apart from waterholes in stream channels and narrow floodplains. On lowlands surrounding the plateaux are floodplains with numerous waterholes, lakes and swamps along the rivers and extensive permanent or seasonal (ie alternately wet and dry each year according to season) swamps on alluvial plains. The Gulf of Carpentaria lowlands contain seasonal and intermittent (alternately wet and dry, but less frequently and regularly than seasonally) swamps in shallow pans, permanent waterholes in channels and seasonal billabongs, and swamps in fans that drain into the Gulf. Mangroves occur along much of the coastline.

The central zone contains extensive intermittent or seasonal swamps and seasonal lakes and swamps along the floodplains. The southern arid lowland zone contains episodic (dry most of the time with rare and very irregular wet phases) saline lakes and intermittently flooded swamps. Numerous rockholes and small episodic lakes occur in the low ranges that feature in an otherwise flat landscape.

2.2 Drainage pattern

About two thirds of total runoff from Australia occurs in northern Australia (Australian Water Resources Council 1976). The NT comprises parts of four drainage divisions

(Jennings & Mabbutt 1986) that extend into the adjacent states (figure 2b). The Western Drainage division has very little runoff, whilst the Timor Sea and Gulf of Carpentaria divisions have exterior coordinated drainage, and the Lake Eyre division coordinated internal drainage.

Many of the rivers flow seasonally or intermittently. Flows are variable, especially in the more arid areas. Along the northern coast tidal influences can extend 80–100 km upstream, for example on the Adelaide and South Alligator Rivers. Many inland rivers are little more than a chain of elongated waterholes for much of the year. A number of dams and reservoirs have been constructed, generally on minor rivers and streams, to conserve surface water.

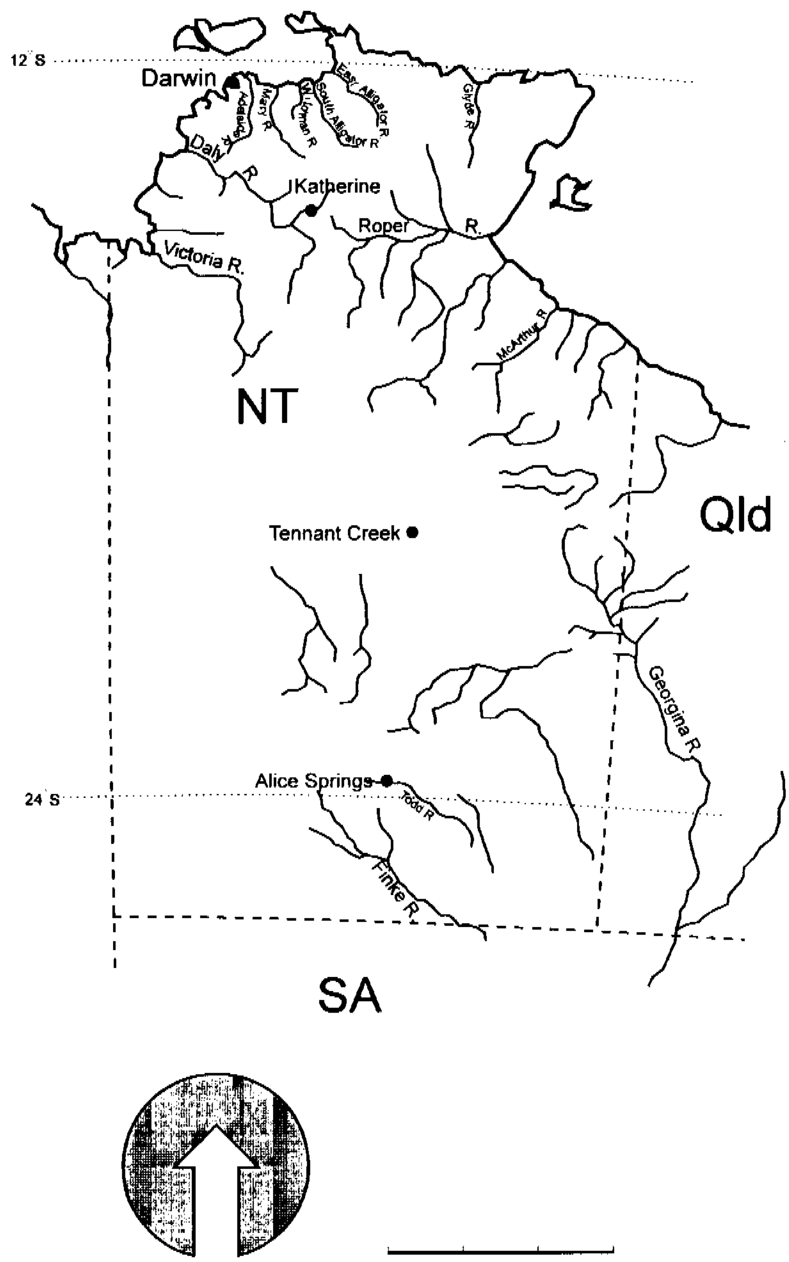


Figure 1 Geographic setting of the Northern Territory showing major population centres and drainage lines

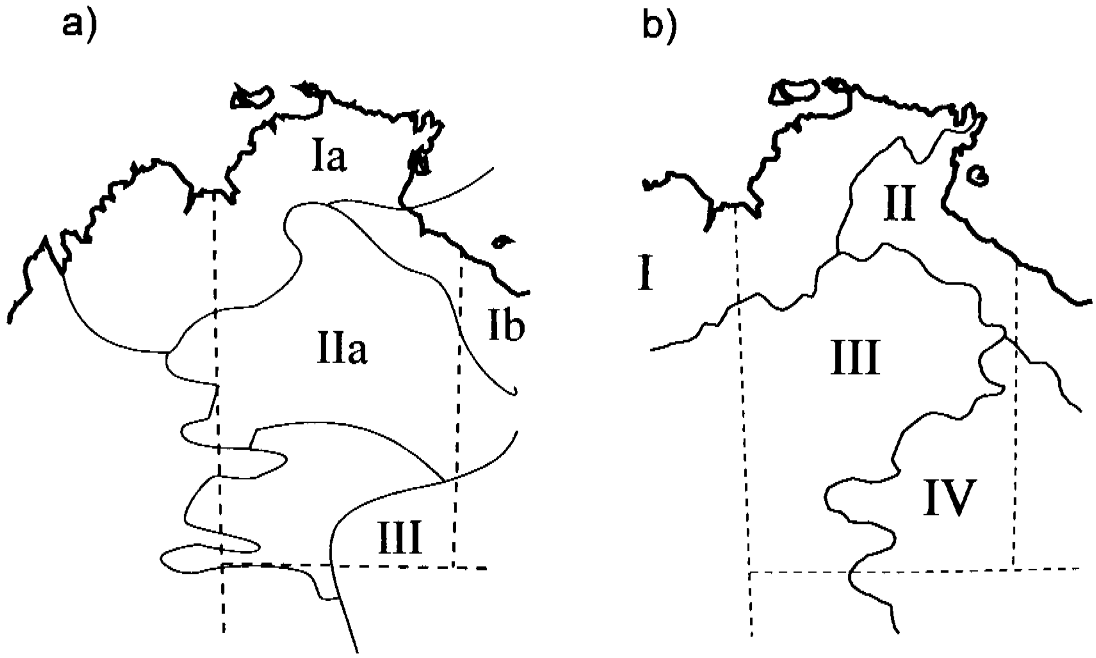


Figure 2a General landform zones (Ia North Australian Plateaux; Ib Carpentaria Fall; IIa Lander-Barkly Tablelands; IIb Central Australian Ranges; III Central Lowlands) of the Northern Territory (adapted from Jennings & Mabbutt 1986), **b** Drainage divisions (I Timor Sea; II Gulf of Carpentaria; III Western; IV Lake Eyre) of the Northern Territory (adapted from Australian Water Resources Council 1976)

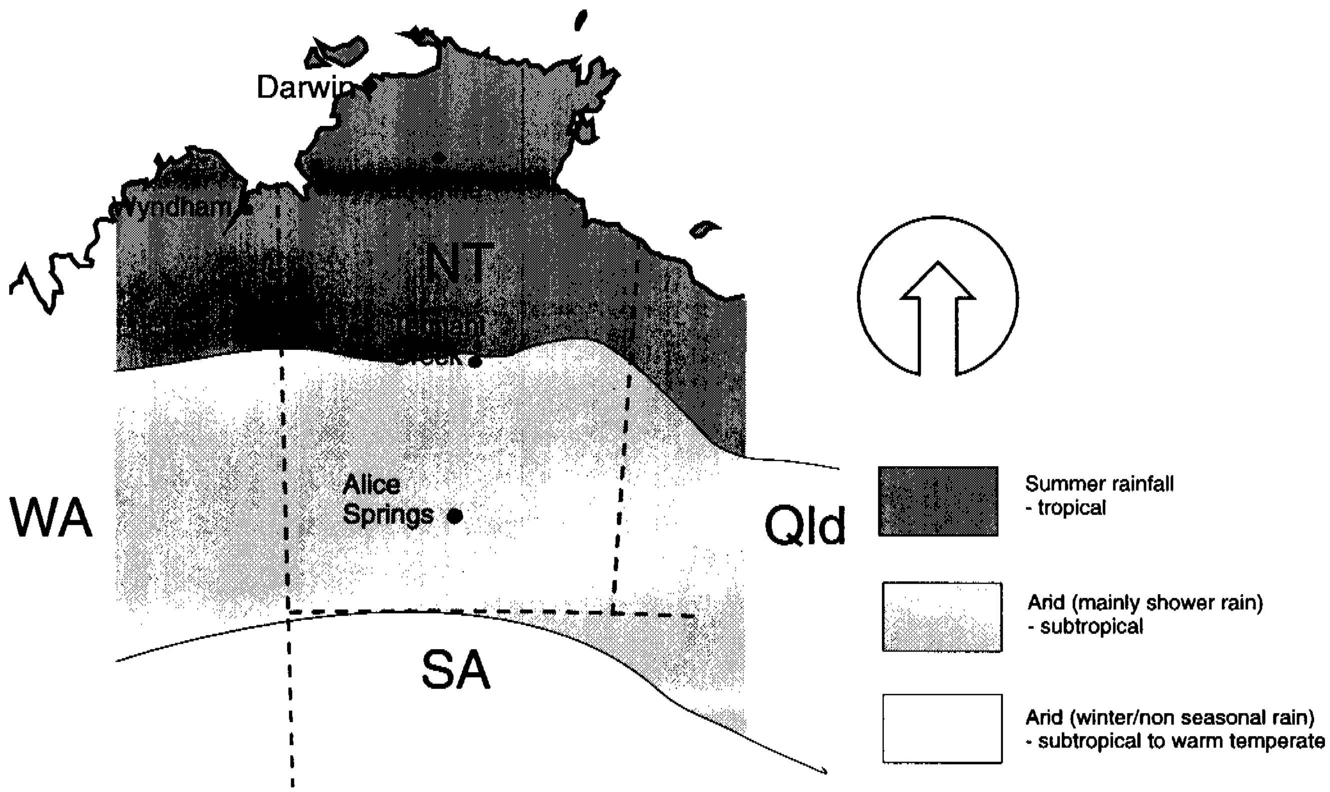


Figure 3 Climatic zones of the Northern Territory (adapted from Bureau of Meteorology 1989)

2.3 Climate

The climate of tropical Australia has been described by Ramage (1971) and Lee & Neal (1984). The two broad climatic zones that encompass the NT are shown in figure 3. In the north there are two seasons – the Wet season, which commences late in the year (November-December) and lasts for 3–4 months, and the Dry season. The most significant features of the Wet season are thunderstorms, tropical cyclones and rain depressions. As cyclones move inland they form rain depressions and are an important source of rain. Rainfall is also associated with monsoonal troughs, which usually produce widespread cloud and rainfall, regional convection that provides localised showers, and easterly disturbances that, in some years, extend the rainy season beyond its normal limits. If there is low rainfall during the Wet season severe drought can occur in the interior. The Dry season is characterised by south-east trade winds.

Mean monthly rainfall values for Darwin are given in table 1, but these figures disguise the considerable variation in timing and duration of the monsoonal rains. While very little rain falls during the Dry season, the amount that does fall is more variable than during the Wet season (Taylor & Tulloch 1985).

Table 1 Mean monthly rainfall (mm), maximum (max) and minimum (min) temperatures (°C), mean monthly evaporation (mm) and mean relative humidity (%) at 9 am and 3 pm for Darwin, Katherine and Alice Springs

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Darwin												
Rainfall	414	341	306	100	21	1	1	6	18	71	143	229
Max temp	31.8	31.4	31.9	32.6	32.0	30.5	30.4	31.2	32.4	33.1	33.1	32.6
Min temp	24.8	24.6	24.5	24.0	22.1	20.0	19.3	20.6	23.1	25.0	25.3	25.3
Evaporation	208	171	192	220	223	216	226	239	249	267	243	226
Humidity 9 am	82	83	83	75	67	62	63	67	71	71	73	77
Humidity 3 pm	70	72	67	52	43	39	38	41	48	53	59	65
Katherine												
Rainfall	233	214	163	33	6	2	1	1	6	30	87	194
Max temp	35.0	34.3	34.5	34.0	32.1	30.0	30.1	32.5	35.4	37.7	38.0	36.5
Min temp	24.0	23.7	22.9	20.4	17.1	14.1	13.2	15.5	19.6	23.6	24.7	24.4
Evaporation	199	146	168	195	197	165	193	232	273	313	277	247
Humidity 9 am	77	81	77	64	58	56	52	52	51	56	61	70
Humidity 3 pm	53	55	49	36	34	31	27	25	25	27	33	44
Alice Springs												
Rainfall	35	41	36	14	19	14	15	11	9	21	25	37
Max temp	36.0	34.9	32.5	27.9	22.8	19.8	19.4	22.3	26.6	30.8	33.5	35.4
Min temp	21.2	20.6	17.4	12.6	8.4	5.2	4.0	6.1	9.9	14.7	17.8	20.1
Evaporation	403	336	310	240	155	120	124	155	240	310	330	372
Humidity 9 am	33	38	39	45	56	65	59	46	34	30	28	30
Humidity 3 pm	20	23	22	25	31	34	30	24	19	18	18	19

(Sources: Bureau of Meteorology, Darwin. Mean monthly evaporation data for Katherine supplied by CSIRO, Tropical Ecosystems Research Centre)

The pattern of climate in the southern region has been described by Slayter (1962) who has identified the south-easterly trade winds high pressure belt as the dominating influence. During the warm months (the temperate summer months) the south-east trade winds are interrupted by intrusions of moist air from tropical low-pressure troughs to the north. Most of the annual rainfall comes from violent convectional thunderstorms.

The monsoonal northern region has warm to hot temperatures all year round while, in the south, mild temperatures occur during the Dry season (table 1). Overnight frost can occur at sites in the south. In the Wet season warm temperatures in Darwin are accompanied by high relative humidity of about 80% compared to about 30% in Alice Springs (table 1). Cloud cover is greatest during the warm Wet season, decreasing over the dry interior and allowing overnight radiative cooling.

2.4 Population

The population of the NT is approximately 170 000 with some 77 000 in Darwin. Other major population centres are Katherine (8 500), Tennant Creek (3 200) and Alice Springs (25 000) (Australian Bureau of Statistics 1996). Almost 70% of the population resides in urban areas. Many smaller settlements are located along major transport routes and in association with pastoral, tourist and recreation, and mining activities. Aboriginal people have also established many small settlements known as outstations.

2.5 Biogeographical regions

The Australian landmass has been divided into interim biogeographical regions (Thackway & Cresswell 1995) on the basis of climate, lithology/geology, landform, vegetation, flora and fauna, land use and, where necessary, other attributes. The information base for this delineation was not uniform and further effort is required to verify all boundaries and descriptions. The biogeographical regions in the NT are shown in figure 4 and described in Appendixes 3 and 4. For convenience of summarising the information on wetlands of the NT the geographic area of the NT has been divided into three broad regions – northern, central and southern regions. The information presented in the text that follows is summarised on a biogeographical basis for each of these regions (Appendix 4).

3 Current knowledge of wetland resources

Classification and inventory of wetlands are processes designed to provide a summary of knowledge on wetlands and their resources. The classification of wetlands is beset with difficulties and often consumes an inordinate amount of time and effort (Finlayson & van der Valk 1995, Scott & Jones 1995). A summary of approaches taken for wetland classification at national and international levels can be found in Finlayson and van der Valk (1995). These authors stress that classification should be used to promote unity of purpose and not serve as a dampener to further innovation and management.

3.1 Wetland definition and classification

The term 'wetland' groups together a wide range of habitats that share a number of common features, the most important of which is continuous, seasonal or periodic standing water or saturated soils. Despite a number of national/regional wetland surveys (see McComb & Lake 1988, Finlayson & von Oertzen 1993, Pressey & Adam 1995) there is no standard definition of wetlands in Australia (Barson & Williams 1991, Pressey & Adam 1995). The recent

Directory of Important Wetlands in Australia (Usback & James 1993) uses the Ramsar wetland definition

> '... wetlands are areas of marsh, fen, peatland, or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.'

Pressey & Adam (1995) report that acceptance of the Ramsar definition for wetlands within Australia is still uncertain.

The only comprehensive overview of Australian wetlands has been provided by Paijmans et al (1985). They chose a classification scheme that was deliberately loosely defined and lacking in detail. The overview consisted of a continent-wide analysis of the occurrence and

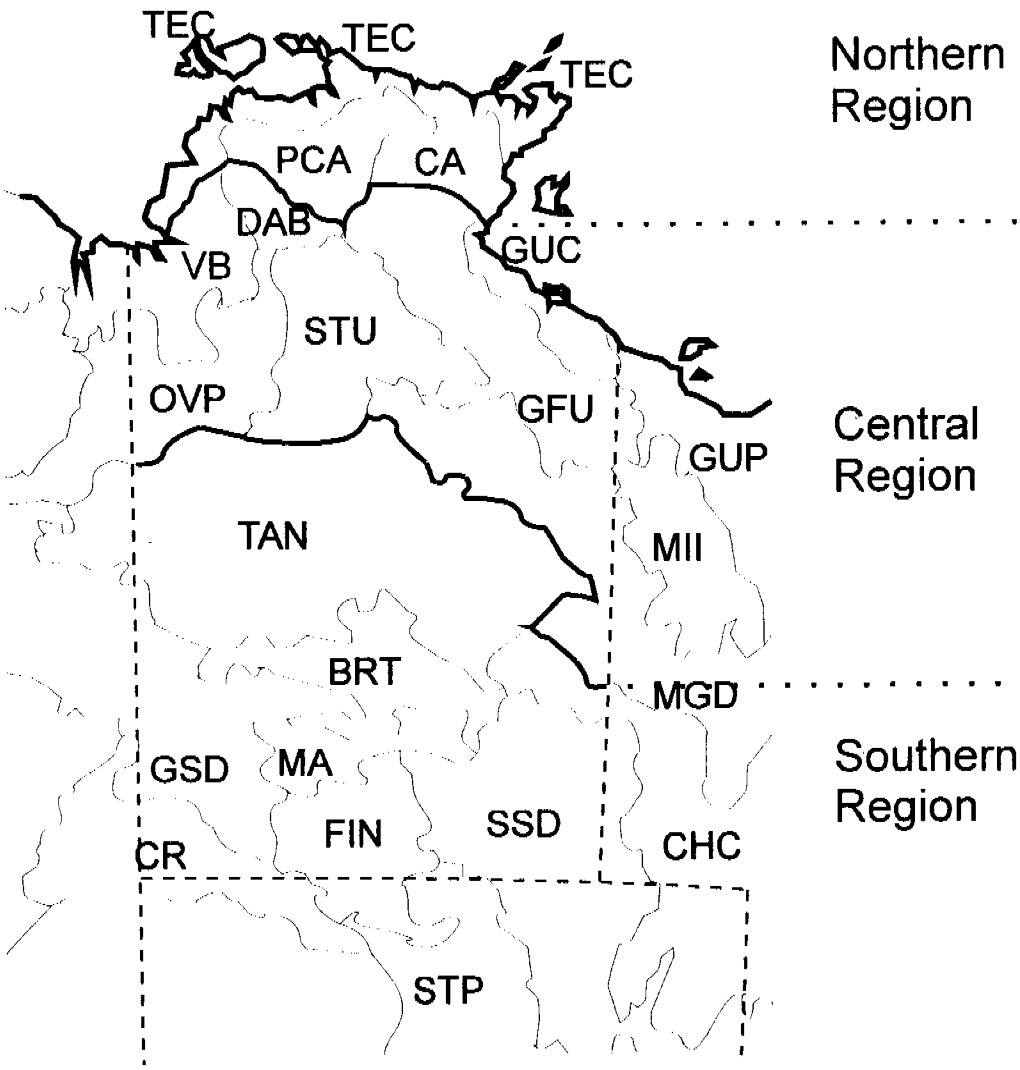


Figure 4 Interim biogeographical regions of the Northern Territory, (provided by ERIN and based on Thackway & Cresswell 1995) with the three broad geographical regions (Northern, Central and Southern) used as the basis for describing wetlands in this overview. The codes for the biogeographical regions are given in Appendix 3

density of wetlands on 1:250 000 topographical maps. A dyeline map of wetlands over the entire continent at a scale of 1:2 500 000 was prepared from the more detailed map analyses. The wetland definition adopted for this overview is

> '... land permanently or temporarily under water or waterlogged. Temporary wetlands must have surface water or waterlogging of sufficient frequency and/or duration to affect the biota. Thus the occurrence, at least sometimes, of hydrophytic vegetation or use by waterbirds are necessary attributes'.

The classification adopted by Paijmans et al (1985) is a three tiered system with categories, classes and sub-classes. Other classifications were not adopted (see Finlayson & von Oertzen 1993) as they were not universal or only emphasised one particular aspect of wetlands.

A key deficiency in classification hierarchies is the overlap of biophysical features among categories and for classes. These maps were based on data collected by the herbarium since 1965 (see Acknowledgments) and were prepared by ERIN (A Bull, pers comm). For the freshwater wetland classes analysed, there is a large degree of overlap between species location (figures 5–8) that appear to reflect drainage lines and basins and not necessarily differences in wetland. Thus, the classification hierarchy is lacking in spatial meaning or relevance.

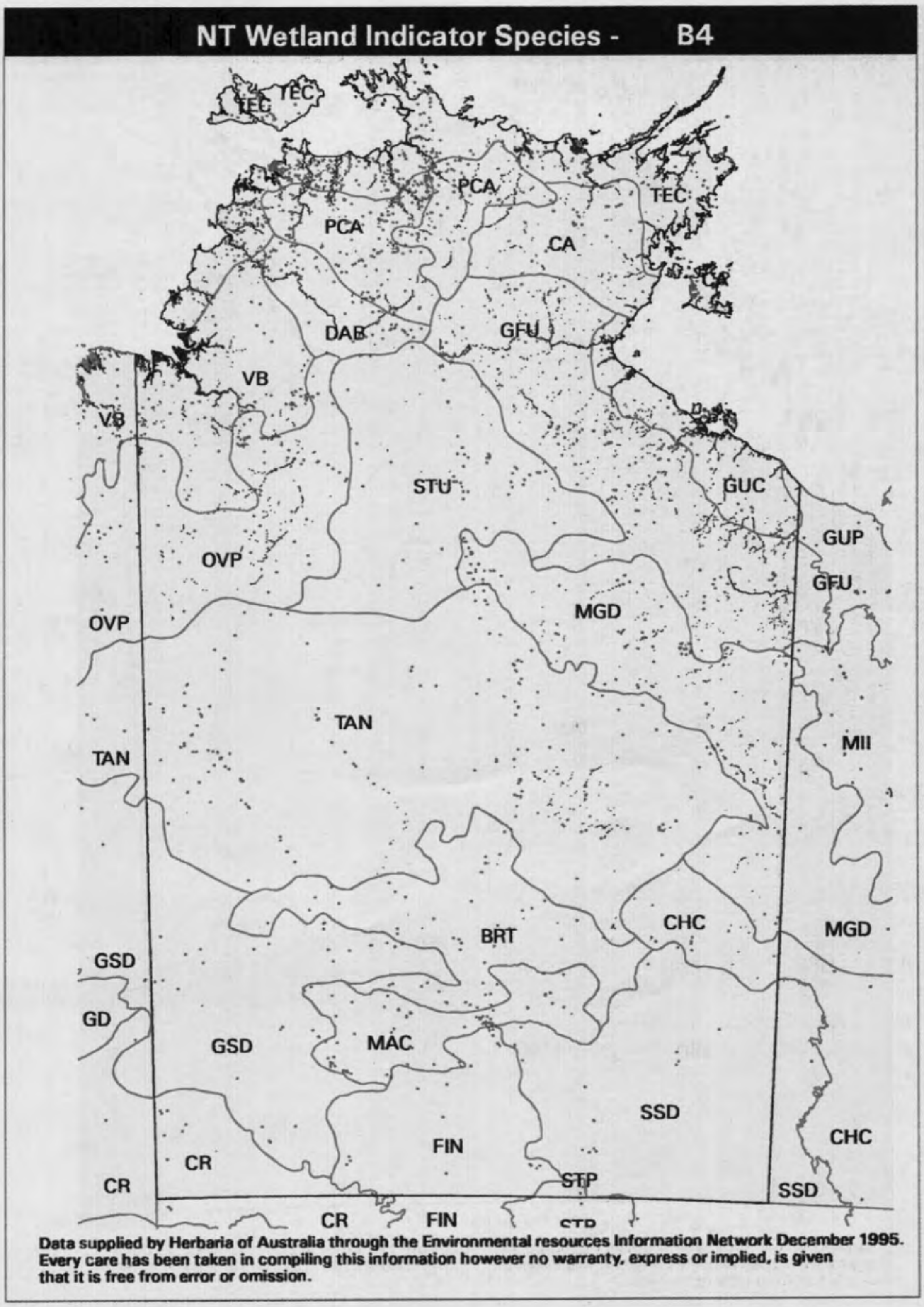
In view of the problems with classification the wetland categories chosen for use in this overview (table 2) are purposefully broad and thereby only reflect the broad physical and biological linkages between habitats. Thus, the categories are not tightly defined, but they do include both the coastal and intertidal wetlands as well as those found inland.

Whilst adopting the simple classification given in table 2 it is stressed that further attention to wetland classification, especially habitat-species interactions and geomorphic relationships (see, for example, Semeniuk 1987, Semeniuk & Semeniuk 1995) is required before adopting a more detailed system. The simplified system chosen for use in this overview is a reflection of the inadequate nature of wetland classification in northern Australia.

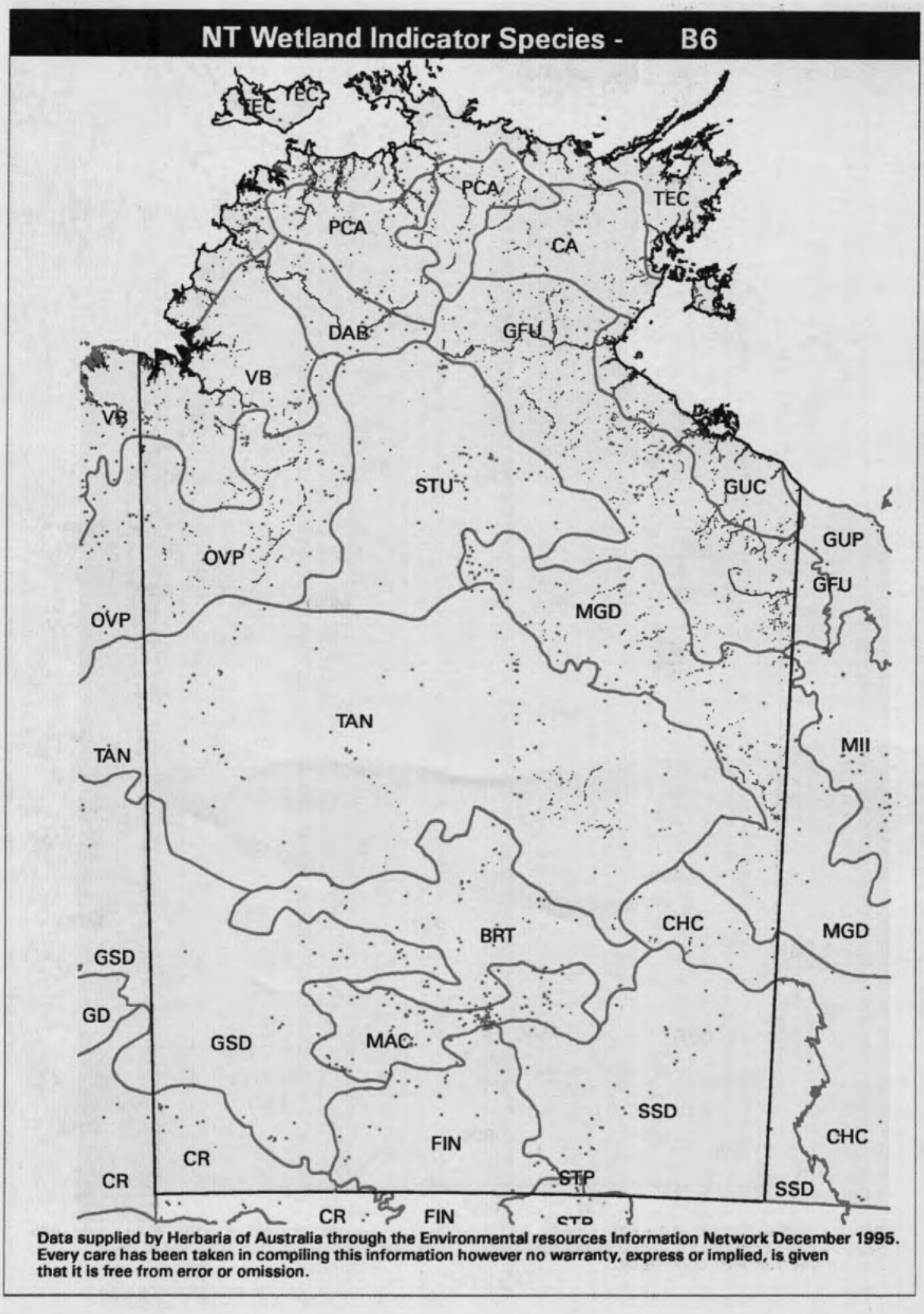
Table 2 A simplistic and interim classification system for wetlands of the Northern Territory (based on Usback & James 1993 and Finlayson et al 1988). The general occurrence of wetland categories within the three broadly delineated regions of the Northern Territory is also shown

Wetland categories		Region of the NT
1	Coastal salt marshes	Northern/Central region
2	Mangrove swamps	Northern/Central region
3	Freshwater lakes and swamps	Northern/Central/Southern region
4	Floodplains	Northern region
5	Freshwater ponds	Northern/Central/Southern region
6	Seasonal and intermittent saline lakes	Southern region

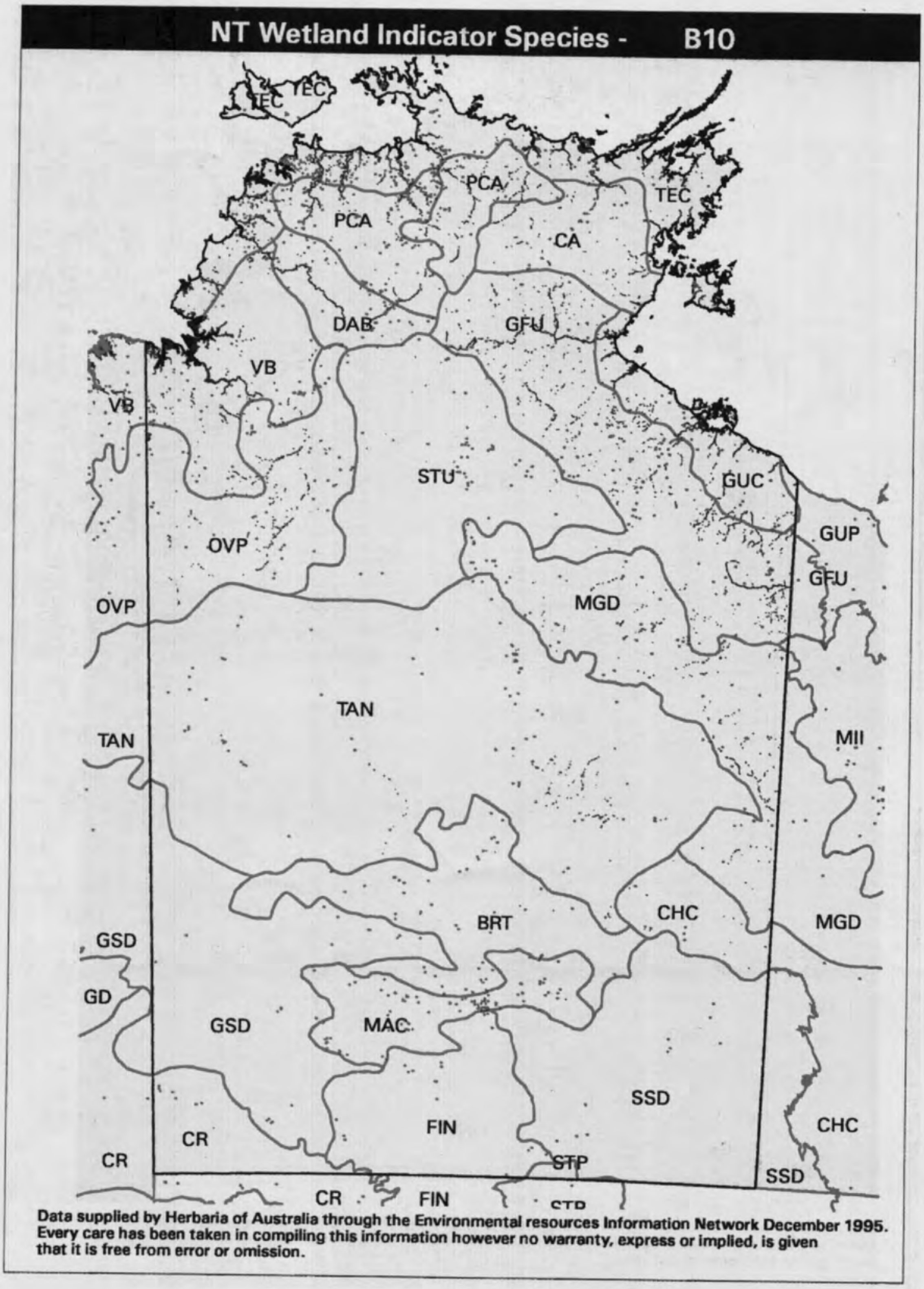
Figures 5–8 indicate the distribution of four wetland classes used in the national wetland directory (Usback & James 1993) and are based on herbarium records held at ERIN (A Bull, pers comm). A list of the plant species in each class is given in Appendix 1. (Species distribution is shown by green dots. Rivers and streams are shown in blue.)



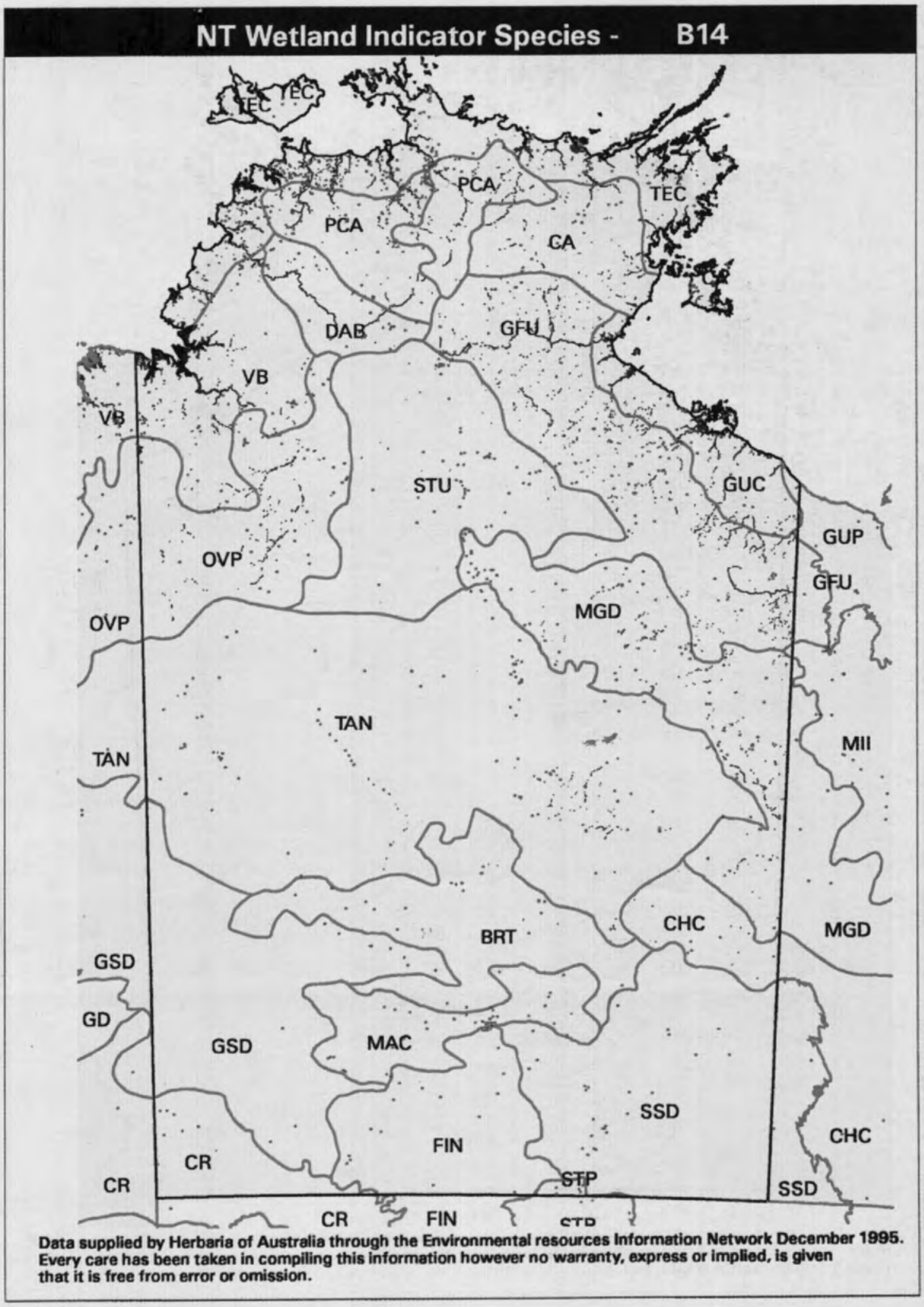
Figures 5 Indication of the distribution of riverine floodplains (class B4) used in the national wetland directory (Usback & James 1993) and are based on herbarium records held at ERIN (A Bull, pers comm). A list of the plant species in each class is given in Appendix 1. Species distribution is shown by the green dots. Rivers and streams are shown in blue



Figures 6 Indication of the distribution of seasonal/intermittent freshwater lakes (class B6) used in the national wetland directory (Usback & James 1993) based on herbarium records held at ERIN (A Bull, pers comm). A list of the plant species in each class is given in Appendix 1. Species distribution is shown by the green dots. Rivers and streams are shown in blue



Figures 7 Indication of the distribution of seasonal/intermittent freshwater ponds/marshes (class B10) used in the national wetland directory (Usback & James 1993) based on herbarium records held at ERIN (A Bull, pers comm). A list of the plant species in each class is given in Appendix 1. Species distribution is shown by the green dots. Rivers and streams are shown in blue



Figures 8 Indication of the distribution of freshwater swamp forests (class B14) used in the national wetland directory (Usback & James 1993) based on herbarium records held at ERIN (A Bull, pers comm). A list of the plant species in each class is given in Appendix 1. Species distribution is shown by the green dots. Rivers and streams are shown in blue .

3.2 Wetland inventory

It is not possible, based on current inventory information, to accurately depict the extent of wetlands across the NT. A broadscale inventory is lacking. The maps produced by Paijmans et al (1985) are the only ones available for the entire NT and these are shown in figure 9. The maps do not specifically delineate discrete wetlands but they do illustrate a number of key points about the distribution of wetlands in the NT that reflect the general landforms and climate:

- general low occurrence of permanent swamps and lakes;
- permanent and near permanent wetlands occur along the coast and in the northern area;
- episodic lakes and land subject to inundation are spread across the central and southern regions; and
- generally dry wetlands occur across most of the central and southern regions

It is emphasised that these maps are only useful on a broadscale basis. Not all wetland classes used by Paijmans et al (1985) are shown. Further more detailed analyses could be obtained from species records as shown in figures 5–8.

Without a complete inventory of wetlands, management for conservation and sustainable utilisation of wetlands will, in part, continue to be underpinned by an ad hoc information base. The unevenness of current inventory information is shown by the list of datasets pertaining to wetlands in the NT (Appendix 2). It is evident from this list that the inventory process (for both flora and fauna) is more advanced in the northern region of the NT than in the central and southern regions. In fact, it is comparatively poor for the latter regions.

Although the wetland inventory is patchy the general state of data collection and curation by the Parks and Wildlife Commission of the Northern Territory (PWCNT) is well advanced. A great deal of effort is being devoted to the collation and consolidation of records of the historical and contemporary distribution of flora and fauna in the NT. A meta-database (or data directory) is under development to record all known datasets, both digital and non-digital, held by the PWCNT (A Fuchs, pers comm). These include the Fauna and Flora Atlases that extend across the NT and contain information on wetland species.

Further major datasets are held by other NT agencies. For example, long-term, detailed and on-going datasets are being collected on the hydrography of major coastal water catchments by the Power and Water Authority (PAWA). The Department of Primary Industry & Fisheries (DPIF) maintains databases on both terrestrial and aquatic noxious weeds. The Weeds Branch of DPIF is concerned primarily with the management of declared noxious species of weed that affect primary production, with little attention given to inventory and management of environmental weeds. Fauna databases are more numerous (Appendix 2). Information from these databases is summarised below. A synthesis of these data has commenced (P Whitehead, pers comm).

3.3 Wetland evolution

The geomorphological origins of wetlands in the NT are discussed by Christian & Stewart (1952), Mabbutt (1962), Williams (1969) and Galloway (1976). The major wetlands of the central and southern regions are associated with the plains and basins that surround the Central Highlands, a landscape that dates from the Mesozoic era. The Amadeus basin, the Tanami sand plain and the Barkly tableland were occupied by extensive seasonal lakes

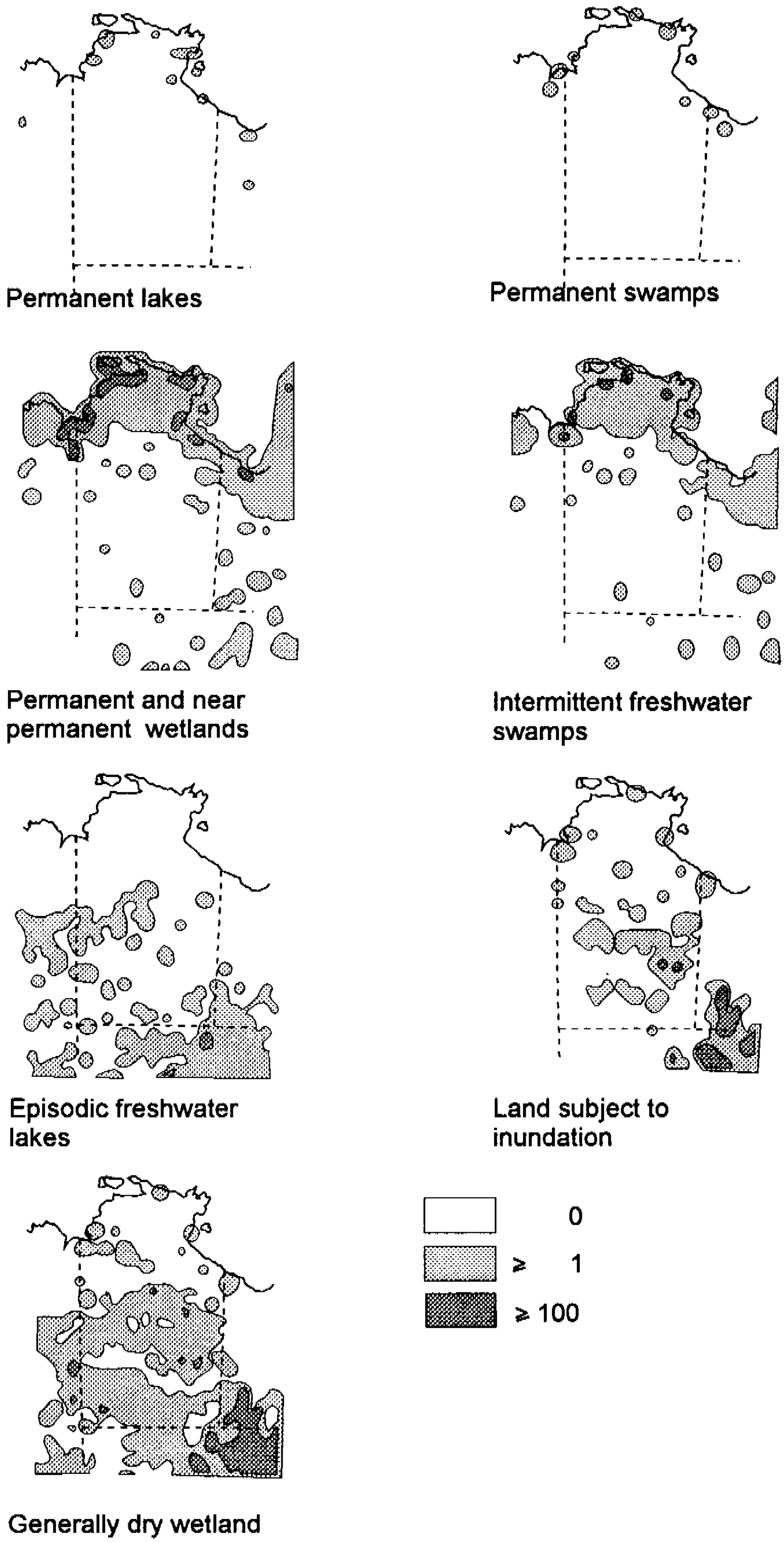


Figure 9 Occurrence of selected wetland categories in the Northern Territory. From Paijmans et al (1985). Code is the frequency of wetlands per 1:250 000 topographical map used in the survey

during the Tertiary which eventually retracted and left extensive limestone plains. The vestiges of these can be seen in the present Lake Amadeus, the palaeo-channels of the Tanami Desert and the black-soil, intermittent lakes and swamps of the Barkly tableland.

By way of contrast, the extensive wetlands of the Top End in the northern region are of recent origin. The Tertiary land surface has been almost completely removed, and lowland plains are derived from late-Tertiary sediments. The coastline emerged in recent times and the extensive areas of estuarine clay floodplains were formed during the Holocene. The sea level was reached about 6 500 years BP (Chappell & Grindrod 1983) making it possible for mangrove colonisation. The mangrove swamps accumulated sediments, which progressively led to their replacement, about 5 500 years BP, with saline and hypersaline plains (Woodroffe et al 1985b). Levees formed along the channels, reducing the extent of saline flooding, and non-saline vegetation invaded the plains which, along with seasonal inundation and deposition of freshwater sediments, led to the formation of the present freshwater wetlands within the last 1 500 years (Woodroffe et al 1985a).

4 Wetland characteristics

Much of the information presented below is taken from past reviews of northern Australian wetlands (eg Finlayson et al 1988, Finlayson & von Oertzen 1993, Jaensch 1994, Finlayson 1995, Jonauskas 1996) and the databases referred to in Appendix 2 and summarised in Appendix 4. The wetland categories are those shown in table 2.

4.1 Coastal salt marshes

Coastal salt marshes encompass intertidal salt marshes and supra-tidal salt flats. Intertidal salt marshes occur extensively along the Arnhem Land/Gulf of Carpentaria coast and are often physically separated from the salt flats by sand dunes and cheniers.

Tropical coastal salt marshes contain considerably fewer plant species than those in temperate areas (Stanton 1975, Saenger et al 1977, Specht 1981). Salt flats lacking vegetation are more common (Macnae 1966) and are found alongside many of the coastal mangrove communities (eg the East Alligator and South Alligator Rivers). Saenger et al (1977) list seven species of salt-marsh plants for the northern coast and three more for the Arnhem Land/Gulf of Carpentaria coast. Two species, *Batis argillicola* and *Tecticornia australasica,* are confined to the tropics while *Xerochloa barbata* is typically tropical. A large number of plant species occupy the landward fringe of salt-marshes (and mangroves).

Intertidal mudflats and, to some extent, the exposed salt flats and marshes attract large numbers of migratory shorebirds and are particularly important for *Limosa lapponica* (bar-tailed godwit) and *Calidris tenuirostris* (great knot) (Watkins 1993). Many of these birds utilise the bare mudflats that are exposed at low tide.

4.2 Mangrove-swamps

The distribution of mangroves in the NT has been investigated reasonably thoroughly (Hegerl et al 1979, Dames & Moore 1984, P Brocklehurst, pers comm). Extensive mangrove coverage, in excess of 20 000 ha, occurs in the Darwin/Bynoe and Buckingham/Arnhem Bays. North-west Arnhem Land and Melville Island have 10 000–20 000 ha coverage. Total coverage is about 4 150 km^2 varying from narrow coastal fringes to extensive forests, and up to 40 km inland along rivers (Galloway 1982).

4.2.1 Flora

Wells (1985) determined three major site categories, that reflect local climatic variations for tidal wetlands. The first category has the lowest level of floristic diversity, with 4–14 mangrove species, and covers the relatively seasonally arid area within the Gulf of Carpentaria and Joseph Bonaparte Gulf. The less arid coasts of the Arafura and Timor Seas comprise the intermediate category with 11–16 mangrove species. The northern coastline with high annual rainfall, some falling during the Dry season, is the most floristically rich with 14–21 species. A group of ubiquitous species occur across these sites, whilst others are not as widely distributed.

The forests vary from having distinct vegetation zones to being completely mixed, with the frequency of inundation by tidal water, freshwater flow, soil type and drainage being important controlling factors (Chapman 1977, Bunt et al 1982). The most common species is *Avicennia marina* which can tolerate a wide salinity range (Macnae 1966). *Rhizophora stylosa* is found in highly saline areas inundated regularly by tides. It occurs either as a pioneer species or in monospecific stands behind other pioneering species. *Ceriops tagal* is also a common species and although it is intolerant of freshwater, it can colonise the landward, unconsolidated clay edge of the mangal. Dames and Moore (1984) present distribution maps for 26 species.

A generalised zonation pattern, in order of greatest to least degree of inundation, for river-fringing, lower estuary and coastal areas of the Alligator Rivers Region has been suggested by Hegerl et al (1979): *Sonneratia alba* open forest; *Rhizophora stylosa* low closed or closed forest; *Ceriops tagal* low closed forest; *Avicennia marina* closed scrub to low shrubland; and saltmarsh chenopods. A similar pattern was not discernible for associations bordering creeks draining into the East Alligator river.

4.2.2 Fauna

The saltwater or estuarine crocodile (*Crocodylus porosus*), a number of birds, snakes, lizards and turtles, plus mammals such as the fruit and insect-eating bats, water rats, feral buffaloes and pigs utilise the mangrove habitats (Hegerl et al 1979, Milward 1982). General accounts of the biota in Australian mangrove-swamps are given by Saenger et al (1977) and Hutchings & Recher (1983). Hanley (1995) reports that the invertebrate fauna is poorly known. Detailed accounts of the fauna are not common (see Hanley 1995), with crocodiles being a well known exception.

Crocodylus porosus is a large (less than 7 m long) and obvious member of the mangrove fauna. It is an opportunistic feeder, the younger ones eating mainly invertebrates, including crabs, whereas the older, larger ones eat more vertebrates including fish, birds, wallabies, and reptiles (Taylor 1979). Unlike the freshwater species (*Crocodylus johnstoni*), the saltwater crocodile is found in both tidal and freshwater sections of rivers, tolerating salinities from 0–35% (Taylor 1979). Since commercial hunting ceased in 1971 there is evidence that the numbers, sizes and total biomass of estuarine crocodiles are increasing and in some areas resulting in the exclusion of the smaller freshwater species (Webb et al 1983c, Jenkins & Forbes 1985).

4.3 Freshwater lakes and swamps

Permanent lakes and swamps in the NT are all densely vegetated but are rare, occurring along the northern coast. Lake Finniss, a natural lake (c 500 ha) at the edge of the Adelaide River floodplain, usually does not dry out in the Dry season; it is dominated by wetland grass (*Hymenachne* spp) and sedge (*Eleocharis* spp). Melacca Swamp, notable as a saltwater crocodile breeding site, is situated at the opposite side of the flood plain and is spring fed. It has a vegetation community that is uncommon in the NT; tall sedgeland of *Thoracostachyum sumatranum* with ferns and vines. Fogg Dam was built to retain water for the ill-fated rice development scheme. It is relatively shallow and contains many water plants, including the alien weed *Eichhornia crassipes* (water hyacinth). To a large extent the flora and fauna of Fogg Dam is similar to that described for the flood plains along the northern coastal zone (CM Finlayson, pers observation).

Seasonal lakes and swamps occur extensively in the northern and central regions of the NT, becoming less common toward the southern limits of the monsoonal rainstorms. Large seasonal lakes and swamps are rare in the coastal zone except for a suite of lakes near Legune, adjacent to the Keep River floodplain. These basins support extensive beetle grass (*Diplachne parviflora*) and thickets of pea shrub (*Aeschynomene* and *Sesbania* spp).

In the central region, extensive seasonal freshwater lakes and swamps occur on black cracking clay associated with the internal drainage basins of Sturt Creek (Birrindudu Wetlands 20 000 ha, Nongra Lake 6 000 ha) and several creek systems of the Barkly Tableland (eg Tarrabool Lake 220 000 ha, Lake Woods 45 000 ha, Lake Sylvester system 100 000 ha). Inundation occurs in most years but to highly variable depths; the lakes may hold water for more than 12 months following especially wet years (eg mid 1970s, 1993).

Knowledge of the flora of these central wetlands (Perry & Christian 1954, Fleming et al 1983, Jaensch 1994, Jaensch et al 1995) is less substantial than for northern swamps, but is sufficient for broad classification. *Chenopodium auricomum* (northern bluebush) occurs throughout and dominates some basins whereas *Muelenbeckia cunninghamii* (lignum) is also widespread but dominates mainly around creek deltas (largest area: Lake Woods). *Aeschynomene* spp (pea shrubs) and *Sesbania* spp or *Panicum laevinode* (pepper grass) are seasonally extensive in some basins. *Oryza australiensis* (wild rice) and *Echinocloa turnerana* (channel millet) are now scarce, probably due to extensive grazing by cattle. *Nymphaea* spp (lillies) and *Pseudoraphis spinescens* (floating grassmats) occur on deep waterholes where creeks enter the lakes; *Ipomea aquatica* (creeper) and *Marsilea* spp (nardoo) are associated with lignum swamp. As waters retreat, lush growth of *Sporobolus mitchelli* (grass), *Cyperus* spp (eg sedge) and *Psoralea cinerea*, *Ludwigia perennis* (herbs) appear.

Parts of these basins, usually subject to less prolonged inundation, are dominated by *Eucalyptus microtheca* (coolibah) woodland. The outer parts of Tarrabool Lake support more than 100 000 ha of coolibah woodland which constitutes probably the largest wooded swamp in tropical Australia (Jaensch 1994). *Acacia stenophylla* (river cooba) occurs in patches, especially around creek deltas (notably Birrindudu Wetlands) and is favoured by herons and egrets for breeding colonies (Jaensch 1994). Nongra Lake has tall stands of *Acacia maconochieana*, an uncommon type of wooded swamp in the NT.

In wet years, the wetlands fill and provide valuable habitat for waterbird breeding and refuge for 6–12 months, supporting in the order of 500 000 to one million waterbirds (Watkins 1993, Jaensch 1994, Jaensch & Bellchambers 1996). Overall, some 75 waterbird species have been recorded from these lakes with 41 of them breeding (Jaensch 1994). In the Lake Woods/Lake Sylvester region there are at least six major breeding colonies of ibis, herons, egrets and spoonbills (R Chatto, pers comm). Significant numbers of Anseranas semipalmata (magpie geese) that mainly use near-coastal wetlands were found to successfully breed in Lake Woods (Jaensch 1994). Breeding species include *Malacorhynchus membranaceus* (pink-eared duck) and Dendrocygna eytoni (plumed whistling-duck) and Pelecanus conspicillatus (Australian pelican).

As the lakes dry out the shallow edges of the retreating lakes are utilised by large numbers of migratory shorebirds (Gibson & Southgate 1982, Fleming et al 1983, Jaensch 1994, Jaensch & Bellchambers 1996). As these wetlands support such large numbers of waterbirds it is assumed that fish, frog and invertebrate faunas are also extremely abundant, but very little survey work has been done.

4.4 Floodplains

Seasonally and intermittently flooding plains occur along most Top End rivers that are influenced by monsoonal rains and have a very pronounced seasonal inundation cycle (Finlayson et al 1988, 1990b). The floodplain systems are subject to natural, and in some cases severe variation as a result of the highly seasonal and unpredictable nature of the climate. The northern climate and hydrology have a marked influence on the floodplain habitats. The permanent waterholes (that are often inaccurately called billabongs – Paijmans et al 1985) have a generalised uniformity of physico-chemical conditions during periods of stream flow and a progressive increase in solute concentrations during the Dry season. More detailed accounts are available in Walker & Tyler (1984), Bishop & Forbes (1986) and Morley et al (1984) and summarised in Finlayson et al (1990b).

4.4.1 Flora

Detailed vegetation surveys have been undertaken on the floodplains between Darwin and the East Alligator River (Story 1976, Williams 1979, Morley 1981, Burgman & Thompson 1982, Sanderson et al 1983, Taylor & Dunlop 1985, Bowman & Wilson 1986, Finlayson et al 1989, 1990b, 1993, Whitehead et al 1990). A broadscale vegetation survey, and vegetation classification of the major floodplains between the Moyle River in the west and the Glyde River in the east was undertaken in 1990 (Wilson et al 1991). It is planned (Whitehead 1996) to combine the broad habitat descriptions used for the Vegetation Map of the NT (Wilson et al 1990) with the floodplain vegetation surveys done by Wilson et al (1991) to provide a systematic assessment of the distribution of plant species and communities on these floodplains. A detailed floristic survey of the Arafura Swamp has recently been undertaken, however, other areas of Arnhem Land have not been surveyed in detail (P Brocklehurst, pers comm). General descriptions of the distribution of the major plant species on the floodplains can be made from previous surveys (J Taylor & P Bayliss unpubl, Wilson et al 1991).

The weeds *Mimosa pigra* and *Salvinia molesta* (both classified as noxious weeds in the NT) have become prominent features of some floodplains (see below). However, alien weed species comprise less than 5% of the flora (Cowie & Werner 1993, Whitehead et al 1990).

A more detailed analysis of aquatic plant distribution is available for the Magela Creek floodplain. Morley (1981) recognised 36 communities on one section of the floodplain, but this was not reproducible in subsequent Wet seasons (Sanderson et al 1983). To overcome the problems of year to year changes Finlayson et al (1989) used peak Wet season vegetation data from several years to describe and map 10 broad plant communities on the floodplain: *Melaleuca* open forest and woodland; *Melaleuca* open woodland; *Nelumbo* swamp; *Oryza* grassland; *Hymenachne* grassland; *Pseudoraphis* grassland; *Hymenachne-Eleocharis* swamp; mixed grassland and sedgeland; *Eleocharis* sedgeland; and an open-water community. This classification allows for seasonal and annual changes in vegetation associations and dominance.

An outstanding feature of the floodplain vegetation is the variation in floristic composition and foliar cover during the Wet and Dry seasons (Finlayson et al 1990b). The success of the majority of species relies on mechanisms that enable them to survive the Dry season drought (Finlayson et al 1989, 1990a, Finlayson 1993). Whilst there is great seasonal variation the floodplain vegetation communities are relatively floristically simple and species richness is low compared to surrounding forests and woodlands (Taylor & Dunlop 1985, Whitehead et al 1990). The vegetation associations of the floodplains can differ, but the species appear to be cosmopolitan (Whitehead et al 1990).

4.4.2 Fauna

Examination of available data reveals that the Top End flood plains support high numbers of animals (Finlayson et al 1988). These include freshwater and saltwater crocodiles (Webb et al 1983b, Bayliss et al 1986, Messel & Vorlicek, 1986), other large reptiles such as the file snake (Shine 1986a) and freshwater turtles (Legler 1980, 1981, 1982), freshwater fish (Bishop & Forbes 1986, Bishop et al 1986, 1990, 1995), freshwater mussels (Humphrey & Simpson 1985) and a wide assortment of water birds (Morton & Brennan 1986, Bayliss & Yeomans 1990, Morton et al 1984, 1990a,b, 1993a,b).

Large long-lived animals exploit the wetlands by using a high level of mobility and/or by having mechanisms that allow them to withstand periods of little or no nutrient intake. Aquatic reptiles exhibit either, or both, a physiology of periodic or constant low metabolism and slow growth rates, or food habits that lower their dependence on foods provided by the aquatic environment (Seymour et al 1981, Webb et al 1983a). *Crocodylus johnstoni* (freshwater crocodile) eats less during the Dry season than during the Wet season, particularly when the temperature is lower, and a large part of their food comes from the terrestrial environment (Webb et al 1982). Adult *Crocodylus porosus* (saltwater crocodile) also consume foods of terrestrial origin. Smaller *Crocodylus porosus* are opportunistic feeders and mainly eat invertebrates (Taylor 1979). The Arafura file snake (*Acrochordus arafurae*) reproduces less frequently than other snakes (Shine 1986b) and possess a metabolic rate that is lower than most other reptiles (Seymour et al 1981, Shine 1986b). Freshwater turtles depend heavily on vegetable foods of terrestrial origin.

Some freshwater fish are dependent on food entering the aquatic environment from terrestrial sources. These include surface feeding species like *Melanotaenia splendida inornata* and *Melanotaenia nigrans* (chequered and black-striped rainbow fish) as well as such highly-specialised species as *Toxotes chatareus* and *Toxotes lorentzi* (the archer and primitive archer fish). Other species, such as *Hephaestus fuliginosus* (black bream) and *Syncomistes butleri* (sharp-nosed grunter), scavenge on material of terrestrial origin, while the forktailed catfish (*Hexanematichthys leptaspis*) is omnivorous.

Of the larger species, *Lates calcarifer* (barramundi) exhibits great mobility, breeding in sea water at the mouth of the river system and then either staying in the salt water or swimming upstream to the fresh water. The juveniles spend their early weeks in brackish coastal swamps, some migrating upstream to the freshwater floodplains. Fish migration occurs during the Wet season (Bishop et al 1995). Recolonisation of the lowland sandy creeks and backflow billabongs in the early-wet results in the most obvious seasonal changes in fish community structure. Movement occurs in both an upstream and downstream direction from Dry season refuge areas on the floodplains and upper escarpment areas.

The floodplains are the prime habitat for 68 bird species (Morton & Brennan 1986, Morton et al 1990a,b, 1993a,b). The numerically dominant species on the floodplains are *Anseranas semipalmata* (magpie goose), *Dendrocygna arcuata* (wandering whistling-duck), *Egretta* *intermedia* (intermediate egret) and *Plegadis falcinellus* (glossy ibis). There are also an additional 18 species of migratory birds from the Charadriidae and Scolopacidae families. Unlike other habitats, the wetlands have a predominance of piscivores, herbivores and species that consume aquatic invertebrates.

Seasonal movement of waterbirds is very pronounced with species migrating between wetlands on a seasonal basis (Morton & Brennan 1986, Watkins 1993, Jaensch et al 1995) and to both the northern hemisphere and southern Australia. The magpie goose is the best known of the waterbirds and the complex interactions that determine its migratory pattern have been well reported and discussed (Frith & Davies 1961, Morton et al 1990a, Whitehead 1987, Whitehead et al 1990). In broad terms, they move to swamps that supply their nesting requirements in the Wet season, and during the Dry season they are influenced by the availability of food and water. The Mary River appears to be an important breeding area and the South Alligator and East Alligator Rivers important Dry season feeding areas.

Broad scale, seasonal changes in distribution occur for other waterbirds, such as *Tadorna radjah* (Radjah Shelduck) and *Dendrocygna arcuata* and *Dendrocygna eytoni* (the whistling ducks) (Morton et al 1990b, 1993a,b). The seasonal patterns differ with the species, but their mobility allows for exploitation of habitats insufficient to support a resident population or, allows for the maintenance of higher population sizes than would otherwise be possible. Species movements have been well documented for the Alligator Rivers Region (Morton et al 1984). These data have been complemented by five years of aerial surveys of many of the floodplain wetlands (R Chatto unpublished); analysis of these data is underway.

4.5 Freshwater ponds

Freshwater ponds are often associated with rivers and swamps as well as being relict habitats in rocky ranges such as the West MacDonnells and the George Gill Ranges in the southern region, and in the sandstone plateau/escarpment country of the northern region. Very little specific information is available on pond habitats in the Top End despite their great tourist appeal in Kakadu and Litchfield National Parks.

Permanent gorge and river pools found in the West MacDonnell Ranges, are among the most isolated freshwater habitats in Australia, and support a rich and abundant invertebrate fauna and eleven species of fish. Of particular importance is the occurrence of the waterpenny, *Scerocyphon fuscus,* an invertebrate species, which appears to have survived from a period when central Australia was much wetter (Davis 1995).

4.6 Seasonal/intermittent saline lakes

The area of saline wetlands in Australia far exceeds that occupied by freshwater. Extensive areas of salt-pans or playas are found in the south-western portion of the NT. In the Amadeus basin, Lake Neale and Lake Amadeus form part of a chain of salt lakes that stretch east almost to the Finke River. Along the axis of the Burt Plain, Lake Bennett and Napperby Lake are part of a similar chain. Straddling the border with Western Australia are the extensive playas of Lake Mackay, Lake White and Lake MacDonald. These are the relics of larger lakes and undergo alternate wetting and drying over long periods. They are very susceptible to wind action which has formed massive dunes and sandy islands in the larger pans.

Fringing the saline lakes is a band of samphire (*Halosarcia* spp), which gives way to a sparse and low tree community of *Melaleuca glomerata* which may have an understorey of chenopods (eg *Bassia* spp). The latter community can also develop along drainage lines well away from the salt lakes.

The salt-lakes contain a high percentage of endemic invertebrate species rather than a wide variety of species. Endemics include the genus *Paratemia* (brine shrimps) and species of the gastropod genus *Coxiella*. Many organisms have also evolved adaptations to cope with periods of drought, for example drought-resistant eggs or larvae, burrowing, and life-cycle adaptations including opportunistic breeding after flooding (Williams & Campbell 1987). The lakes are filled by local rainfall events which lead to an explosion of *Paratemia* spp populations that are exploited by birds such as *Himantopus himantopus* (black-winged stilt), *Cladorhynchus leucocephalus* (banded stilt) and *Recurvirostra novaehollandiae* (red-necked avocet). The annual flowering of *Melaleuca* thickets provides an important nectar source for arid zone honeyeaters.

5 Conservation status of wetlands

The conservation status of wetlands of the NT has not been assessed and indicators of ecological integrity have not been developed. Nevertheless, some generic statements are possible. It is stressed before making these statements that further assessment, monitoring and even audit of the conservation status of the wetland habitats and ecosystems, perhaps through the use of appropriate indices or indicators, is needed. Specific techniques or approaches may need to be developed and/or tested. Given the NT government policy of multiple use of wetlands the concept of acceptable limits of change also needs to be developed. A summary of the information given below is summarised on a biogeographical basis in Appendix 4.

5.1 Ecological integrity of wetlands

Maintaining the ecological character or ecological integrity of wetlands has received an increasing amount of attention in recent years, particularly at the international level (Dugan & Jones 1993, Finlayson 1994). Under the Ramsar Convention for Internationally Important Wetlands the '*ecological character*' of a wetland has been defined as

> '... the structure and inter-relationships between the biological, chemical, and physical components of the wetland. These derive from the interactions of individual processes, functions, attributes and values of the ecosystem(s)'.

Accepting that '*change in ecological character*' is taken to refer to adverse change this is defined as

> 'Change in ecological character of a wetland is the impairment or imbalance in any of those processes and functions which maintain the wetland and its products, attributes and values'.

Accompanying these definitions are guidelines for collecting sufficient information on the components/attributes of a wetland so that a reduction and/or an ongoing imbalance in the ecological character can be identified. However, there is no guidance as to what constitutes a significant change in ecological character.

To assess the ecological integrity of wetlands of the NT, effective monitoring programs are required. As discussed by Finlayson (1994) these should be well designed and be able to answer discrete objectives within realistic time frames. In some instances this will be relatively straight forward (eg the extent of habitat loss due to invasive weed species), but in others it may not be (eg change or loss of ecological functions following invasion by weed species). It is unlikely that these factors could be addressed without recourse to a comprehensive inventory and knowledge base of spatial and temporal variability.

The baseline against which an assessment of ecological integrity of a wetland can be judged will be required. In many instances this baseline will not represent a pristine condition; a decision on what constitutes a valid baseline or reference point for a particular wetland will be needed. Such decisions may be based on scientifically recorded evidence, but could also be made entirely on value judgements.

5.2 Representation of wetlands within the nature reserve system

A protected area estate is one of the most valuable assets for the maintenance and management of genetic, species, community and landscape diversity, as well as key ecological functions and processes. The reserve system is the current mainstay of our conservation platform and should be comprehensive and representative of the diversity of habitats and species. However, given the importance of ecological linkages and interactions within and between wetlands, a reserve system by itself may not be adequate to ensure the sustainability of many wetlands and wetland species.

The existing network of protected areas does not offer comprehensive protection of the faunal or floristic diversity of the NT (Whitehead et al 1992, Woinarski 1992). In order to conserve biological diversity the NT Government has accepted the '*need for a representative system of reserves throughout the Territory's aquatic, marine and terrestrial environments*' (Northern Territory Government 1994) and that the reserve system should be complemented by off-reserve conservation arrangements. Work is continuing on the refinement of methods for selection of reserve sites to optimise the representativeness of their contribution to the protected area estate (Conservation Commission of the Northern Territory 1995). This analysis is required before further progress can be made in conserving wetlands through nature reserves.

The current distribution of reserves is heavily biased toward the northern coastal region (notably the Top End Coastal and Pine Creek Arnhem biogeographical regions). Given the large reserves (especially Kakadu National Park which represents approximately 45% of the total protected area in the NT) wetland types such as mangroves and floodplains are, for the most part, already represented in the protected lands network (Whitehead et al 1992). However, given the extent of interaction between wetlands an assessment of the effectiveness of this network is still required. The Victoria Bonaparte and Ord-Victoria biogeographical regions in the central portion of the NT have over 10% of their area contained in reserves. How well these protected areas conserve their wetland resource is not known.

The reservation status of wetlands in the northern region contrasts with wetlands of the central and southern regions which are largely unrepresented in reserves, except for the gorges and pools of the West MacDonnell National Park. This situation reflects an inadequate level of inventory and research. The need for description and understanding of ecological communities considered to be 'at risk' has been recognised and ephemeral and intermittent wetlands have been tagged as immediate priorities (Northern Territory Government 1994).

5.3 Existing or emerging threats to wetlands

A review for a national wetlands research and development program under the auspices of the federal Land and Water Resources Research and Development Corporation (LWRRDC) is being developed (Bunn 1996). This program will be directed towards land use issues rather than conservation of wetlands *per se*. However, under ecologically sustainable development policies it will have much in common with conservation goals. The LWRRDC review provides a national list of wetland research issues. Those that are of direct relevance to wetland habitat modification in the NT are given below:

- pest species of plants and animals;
- fire and burning regime;
- overgrazing;
- pollution and contaminants;
- tourism and recreational activities; and
- water regime and physical modification

5.3.1 Pest species

The ecological character of many wetlands in Australia has been adversely affected by invasive plants and animals, many of them alien species. For example, fourteen of the top eighteen environmental weeds in Australia invade wetlands (Humphries et al 1991). Twelve of these species are currently found in the NT. (A list of weed species in NT wetlands is given in Appendix 5.) Humphries et al (1991) make the points that tropical wetlands and riparian zones are at great risk from weed invasion.

> '... riparian systems are most heavily invaded within any given environment and are therefore at greatest risk. The importance of these systems, particularly at times of drought, increases the ecological seriousness of this situation.'
>
> 'Tropical wetlands are in critical danger.'

For many of the main pest species the extent of their invasion of wetlands and streams has been described although often incompletely. In many instances the biology of the species may also be known or is being studied. Surprisingly, however, vital information on the ecological changes wrought by these species is often confined to a few isolated studies, if any, and/or anecdotal evidence. Economic analyses of the losses caused by pest species are also not common. Additionally, studies on the social impact of weeds have not been done.

In the following text a general description of major pest species is given.

Acacia nilotica (prickly acacia)

Prickly acacia is native to Africa and West Asia where it is found in acacia-savanna along drainage lines, bores and dams. It currently covers about 7 million hectares in arid to subtropical regions of Queensland (Smith 1995). In the NT, small infestations occur along the Barkly Highway with an outbreak reported on Cattle Creek Station (Ord-Victoria Plains biogeographical region). Currently, all infestations are under control (R Smith, pers comm).

Brachiaria mutica (paragrass), *Echinochloa polystachya* (aleman grass) and *Hymenachne amplexicaulis* (olive hymenachne)

These grass species are commonly referred to as 'ponded pasture species' (Clarkson 1995). Paragrass is a highly invasive alien species that has spread across many wetlands in northern Australia. In places it has been aided by deliberate plantings and in others it has spread from pastoral areas into nature conservation zones (Cowie et al 1986, Lindner 1995, Miller & Wilson 1995, Clarkson 1995). Deliberate planting of paragrass now occurs in the NT for stabilising floodplain surfaces following control of mimosa (Miller & Wilson 1995, Cook & Setterfield 1995) and for 'improved' pasture on the Finniss/Reynolds and Mary River floodplains in particular. Aleman grass and olive hymenachne have only been introduced more recently to a few locations in the NT.

While there is no rigorous scientific data about the impact of these species, there is a lot of evidence that they form a monoculture (Wilson et al 1991) and are, in certain situations, invasive. This means, at the very least, reduced biological diversity in the affected areas, and therefore structural and functional deterioration of the ecosystem. At worst, it could mean the complete alteration/modification of entire ecosystems.

These species present a particularly difficult and even intractable problem given that pastoralists desire them while conservation authorities are concerned over their potential to completely alter the ecological character of wetlands. Fisheries authorities are also concerned that ponded pastures will prevent freshwater runoff to the estuaries and reduce the primary productivity of these habitats and also prevent migration by juvenile barramundi (Clarkson 1995, Griffin 1995).

Cenchrus ciliaris (buffel grass)
Buffel grass is widespread over much of the southern region of the NT. It has formed very dense stands along all rivers in Central Australia. Very little control occurs and then only in specific areas such as on fire breaks in National Parks where the aim is fuel reduction. A related species *Cenchrus echinatus* (Mossman River grass) occurs in some areas of the Hugh and Finke Rivers (Finke biogeographical region) and is becoming more widespread. It is particularly noticeable around tourist areas and is spreading along river banks.

Eichhornia crassipes (water hyacinth)
This floating introduced species has long been a major weed in Australia (Mitchell 1978, Finlayson & Mitchell 1983, Forno & Wright 1981, Wright & Purcell 1995). Biological and chemical control methods have been implemented and it is not now generally regarded as a serious threat to wetlands, although local problems still occur or could occur (Fulton 1995). It is not known if this change has occurred as a consequence of control measures or whether the plant has established a balance after an initial period of explosive growth. It occupies similar habitats as Salvinia and presumably has a similar, but largely unknown affect on wetlands. A number of infestations have been eradicated in the Northern Territory; an infestation still exists in Fogg Dam.

Mimosa pigra (mimosa)
Mimosa is an aggressive prickly shrub, native to Central America, that can form dense monospecific stands on the floodplains of the Top End. At present it is confined to the coastal floodplains of the Top End Coastal biogeographic region, in an arc extending from the Moyle River in the west to the Arafura Swamps in Arnhem Land (Harley 1992, Lonsdale et al 1995). It covers an estimated 80 000 ha. It is a prolific producer of seeds that are readily dispersed by water, vehicles and animal vectors. There is strong circumstantial evidence to link vehicle movements with new occurrences (Cook et al 1996). Natural expansion of established stands is very fast.

Research efforts have centred on finding suitable biological control agents with a number having been released. Integrated control programs are also in place and incorporate biological control along with the use of herbicides, mechanical removal (chaining), burning and revegetation (Miller & Wilson 1995, Schulz & Barrow 1995). In Kakadu National Park a continuous 'search and destroy' policy has been successfully in controling mimosa for the last decade (Cook et al 1996). Outside the park, however, the situation is very serious and expensive chemical control programs that are partly government funded, are undertaken on pastoral leases and Aboriginal lands (Schulz & Barrow 1995). Management emphasis on control techniques, particularly biological means, continues and importantly, is now complemented by post-control rehabilitation of the formerly infested areas.

Parkinsonia aculeata (parkinsonia)
Parkinsonia is often found around bores, dams and along creeks and riverbanks (Smith 1995). It is widespread in the NT with prominent outbreaks on pastoral leases on the Barky Tablelands and in the Victoria River District (Mitchell Grass Downs, Victoria Bonaparte and Ord-Victoria Plains biogeographical regions) and can dominate the vegetation near watercourses and ephemeral lakes (D Gracie, pers comm). Control is undertaken by the DPIF using biological control agents along waterways and herbicides away from the major waterways.

Prosopsis limensis (mesquite)
Mesquite is a small tree that is found on heavier clay and loam soils of the Barkly Tablelands where it is on the increase (Smith 1995). Isolated patches occur near Katherine and between Tennant Creek and Alice Springs. Herbicides have been largely ineffective. It is spread readily by stock through ingestion and later defecation, with isolated plants appearing in previously weed free locations (D Gracie, pers comm). A related species *Prosopsis glandulosa* (honey mesquite), has been found on Nicholson Station in Western Australia abutting the NT border. It has not been recorded in the NT where it is a Class C noxious weed – not to be introduced.

Salvinia molesta (salvinia)
This free-floating aquatic fern, originally from South America, has been the centre of much attention in Australia and elsewhere (Mitchell 1978, Finlayson & Mitchell 1982, Harley & Mitchell 1981, Room & Julien 1995, Storrs & Julien 1996). Infestations have been found in the NT at Nhulunbuy, and on the Finniss, Howard, Daly, Adelaide, South Alligator and East Alligator Rivers (Miller & Wilson 1989, Finlayson et al 1994a, Storrs & Julien 1996). Several infestations have been successfully eradicated by the DPIF using herbicides, including a major infestation on the Adelaide River (Miller & Pickering 1988). Generally, management is now reliant on biological control using an introduced weevil that has had variable levels of success (Room et al 1981). Storrs & Julien (1996) have recommended the adoption of integrated control measures with chemical spraying being strategically allied with attempts to spread the weevil to all known infestations.

Despite being a widespread weed in eastern Australia for more than three decades little is known about its ecological affect on wetlands. Salvinia competes directly with other plants for light, nutrients and space. The water under a salvinia mat has lower oxygen and higher hydrogen sulphide concentrations, lower pH, and higher temperature than open water nearby (Mitchell 1978). It also dramatically alters the nutrient status of billabongs (Storrs & Julien 1996), reducing nutrient availability to other biota (Room 1986). However, the extent of ecological change due to salvinia infestations has not been ascertained.

Tamarix aphylla (athel pine)
Athel pine has been commonly planted around homesteads and bores in arid and semi-arid regions of Australia. It often persists around homesteads, in sandy creeks and river beds (Smith 1995). A major infestation occurs in the Finke River, in a small section of the Ross River near the Ross River Homestead, and parts of the Palmer River (Finke biogeographical region) in the southern region of the NT. Griffin et al (1989) consider that this species has enormous potential to cause environmental degradation on all Central Australian waterways. Currently, control is by herbicide using basal bark or stem injection and has been successful in the Finke River over a 200 km stretch from the headwaters to the Stuart Highway. It is also anticipated that this weed will be eradicated from the Ross and Palmer Rivers by April 1996

(M Fuller, pers comm). However, where there has been no significant control effort, it is expanding rapidly.

Bubalus bubalis (Asian water buffalo)
Prior to the 1980s feral Asian water buffalo proliferated on the coastal floodplains of the NT and were considered responsible for widescale destruction of the native vegetation by direct grazing, trampling and wallowing, and indirectly by destroying levee banks and contributing to premature drainage of freshwaters (Finlayson et al 1988, Skeat et al 1996). Throughout the 1980s the feral herds to the west of Arnhem Land were almost eradicated as part of a national program to prevent diseases being transferred to domestic stock. They still exist in large numbers in Arnhem Land.

The problem, perhaps ironically, is now not so much one of too many buffalo, but one of too few buffalo! The rapid removal of a major grazer from the floodplains and billabongs has resulted in large scale ecological change (Finlayson et al 1991, Finlayson & von Oertzen 1996). Both native and alien plant species have spread to cover the areas formerly laid bare by buffalo; billabongs have become choked with red lilies and sedges, and grasses, including paragrass, have overgrown stream and billabong banks and spread across the floodplains.

It is important to note that the impetus for removing buffalo came from funding provided for disease control in feral stock; environmental concerns were not to the forefront (Skeat et al 1996). Given that funding was not allocated for large scale environmental management it is expected that buffalo numbers could naturally increase again in areas such as Kakadu after the disease eradication program funding ceases in 1997. The potential rate of increase is not known. There have also been calls from Aboriginal associations and individuals for the reintroduction of small herds under controlled conditions. The consequences of any increase in buffalo numbers, including active management needs, has not, to date, been addressed on a multi-sectoral basis.

Camelus dromedarius (camels)
Camels concentrate around salt lakes and clay pans in the southern region of the NT (eg in the vicinity of Lake Amadeus/Lake Neale, southern Tanami, Lake Caroline and the northern Simpson Desert). They regularly return to watering points (dams, soaks, bores or native wells) within their area of occupation and are capable of travelling great distances (100–200 km) to find water, whereas native animals, other than birds, are restricted in their movements and depend on a specific source of water to meet their requirements (D Wurst, pers comm). As camels can cause significant damage to these limited water supplies, especially native wells and soaks, their affect on the native wildlife could be devastating in times of drought.

Equus caballus (horse) and *Equus asinus* (donkey)
Horses and donkeys are prevalent in the southern and central regions of the NT particularly in hilly country. Horses are more ubiquitous than donkeys and are also found in the wetter northern region on floodplains. Both are dependent on waterholes for drinking and often die of starvation rather than thirst during droughts (J Reid, pers comm). The extent of their impact on wetlands is unknown, but individual pools can be severely degraded by overgrazing and subsequent erosion.

Oryctolagus cuniculus (rabbit)
The impact of rabbit grazing is severe in the southern region of the NT and tapers off northwards (in the Mitchell Grass Downs biogeographical region). Their activity is mainly focused on calcareous areas including the fringes of salt lakes and other ephemeral wetlands

that are important habitats for endangered native mammal species such as the mala and bettong (J Reid, pers comm). Excessive grazing can devastate the vegetative margins of ephemeral lakes and pools. It is not yet known what effect the rabbit calici virus will have on the NT rabbit population.

Sus scrofa (pig)
The feral pig is widespread over the Australian environment. It has caused widespread damage around the edges of wetlands. This disturbance provides great potential for the establishment of weed species. In the NT there is evidence that pigs have proliferated following the removal of the feral buffaloes from the floodplains (Corbett 1995). This seems reasonable given that many buffalo were shot from helicopters and their carcasses left on the floodplains and that buffalo formerly trampled and destroyed many vegetative morsels that would have been favoured by the omnivorous pigs. However, the influence of climatic factors, for example, on pig breeding success can not be discounted as a contributory factor.

Control of pigs is widely regarded as difficult in certain types of terrain. Control programs utilise trapping, hunting with dogs, poisoning and helicopter shooting. A further factor to consider when assessing the affect of pigs on the environment and the need for control measures is the increasing acceptance of pigs by some Aboriginal people as a food resource and part of their traditional life style. However, pigs are also seen as a major cause of damage in the vicinity of sacred sites.

Bufo marinus (cane toad)
Over the last decade cane toads have moved westwards from Queensland into the NT to the vicinity of the Roper River. The rate of natural spread is approximately 30 km per year (Freeland & Martin 1985). The available data do not support the notion of the cane toad having a long term catastrophic impact on native fauna. No species in Queensland is known to have become threatened or gone extinct as a result of the cane toad's introduction 50 years ago (W Freeland, pers comm). Recent studies on the toad indicate that whilst it is potentially toxic in all stages of the life cycle and is avoided by many predators they are successfully consumed by other species (Alford et al 1995). Some native frog larvae and snails are negatively affected and toad larvae can compete strongly with larval native frogs. There is strong anecdotal evidence that predators such as goannas initially decline after the arrival of cane toads, but after a short period re-establish (W Freeland, pers comm).

Exotic fish
No major exotic fish incursions have yet happened in the NT. This contrasts markedly with the dominance of introduced species, especially trout, carp and mosquito fish, elsewhere in Australia (Fletcher 1986, Arthington 1989, McKay 1989). Localised incursions of several freshwater aquarium species have occurred. Guppies (*Poecilia reticulata*) are established in Nhulunbuy Town Lagoon; platys, mollies and swordtails (*Xiphophorous maculatus, Poecilia latipinna, Xiphophorous helleri*) in Gunn Point Creek (believed to be escapees from the Prison Farm!).

Mosquito fish (*Gambusia holbrooki*) have been actively introduced into much of southern and eastern Australia as a means of controlling mosquitoes. They occur in the NT at localised sites: Railway Dam in Darwin; and at 2 or 3 sites in central Australia that were associated with WWII railway/military establishments. They are voracious feeders and seemingly have a major influence on the structure of invertebrate communities without being very successful in controlling mosquitoes (Lloyd et al 1986).

5.3.2 Fire and burning regime

Fire is a conspicuous element of the northern landscape and remains a contentious issue (Andersen 1996). The regularity of fire in the wet-dry tropics has been assessed in recent years (eg Press 1988, Allan & Willson 1995), but quantifiable information on the effect of fire on wetlands is, on the whole, absent (Douglas et al 1995).

It is considered that the incidence of fire on the coastal floodplains has increased since the removal of large numbers of buffaloes during the 1980s (Roberts 1996). Further, within Kakadu there is a deliberate policy of fire management that attempts, amongst other objectives, to re-establish some semblance of traditional Aboriginal burning (Ryan et al 1995, Roberts 1996). In some instances this has resulted in the death of mature *Melaleuca* trees and certainly more burning of the riparian zones of some wetlands (Roberts 1996). Andersen (1996) questions the emphases within this fire management regime and along with other authors points out that the ecological consequences of burning patterns are, on the whole, poorly known. Roberts (1996) refers to the wealth of traditional Aboriginal knowledge on fire and burning regimes in relation to food availability.

Vast areas of the central and southern regions of the NT are also burned on a regular basis and this would include many intermittently or episodically flooded wetlands. Little direct analysis of the effect of fire on these wetlands has been undertaken.

5.3.3 Overgrazing

Soil erosion, due largely to poor land management, has been a feature of the riparian areas of many large river systems of northern Australia (eg the Victoria River) causing siltation and filling of waterholes, collapse of bank structure and loss of riparian vegetation (Winter 1990). Overgrazing along drainage lines and elsewhere by cattle and feral animals can lead to pronounced seasonal and other changes in run-off patterns and to increased sediment loads. Vegetation changes, chiefly involving the replacement of deep-rooted trees by shallow-rooted grasses, can also lead to marked changes in hydrological patterns as well as changes in water quality, of which increased salinity can be among the most important.

Pastoralism is the major land use outside nature reserves and has had a major influence on wetlands and will, if it has not already done so, reduce the range of wetland habitats (Whitehead et al 1992). Heavily grazed wetland communities tend to converge floristically and introduced pasture species are known to replace the native grasses (Liddle & Sterling 1992, Whitehead et al 1992). In addition to direct changes in the vegetation Griffin (1995, 1996) has identified changes in the primary production cycles having an adverse effect on fisheries production in the estuaries. Overall, very little is known about changes due to grazing. Corbett et al (1996) and Whitehead et al (1992) have reported briefly on vegetation changes in the coastal wetlands as a consequence of changed grazing practices. Griffin (1995, 1996) has likewise briefly described concerns for fisheries production.

5.3.4 Tourism and recreational activities

Tourism is one of the largest industries in the NT (Taylor et al 1985). Visitation has increased enormously and is expected to continue to increase. Tourism and recreational activities in the northern region are strongly influenced by factors such as the presence of water and accessibility. Most recreational activities, particularly by tourists, are correlated with the presence of formed roads. Access to many wetlands is limited for much of the year and recreational use is generally restricted to floodplain edges, billabongs and major channels or creeks. The current low level of recreational impact on wetlands is probably attributable to low population pressures. With increased population growth (currently 3.8% per annum) and tourism (increasing at 15% per annum), however, impacts are expected to increase (Taylor et al 1985).

The environmental impact of recreational fishing probably extends beyond placing pressure on fish stocks, especially the barramundi stocks, which in 1978 appear to have been fished beyond their maximum sustainable yield in some rivers (Grey & Griffin 1979). There is, however, no available information on the consequences of recreational fishing for wetlands of the NT. As access to escarpment gorges is improved increased pressure from recreational fishermen will be placed on the easily caught black bream, *Hephaestus fuliginosus*.

Hunting has always been a popular activity in wetlands. Hunting of geese by non-Aborigines has recently undergone increased regulation and has been subjected to intensive research and monitoring. In view of an expected increase in hunting activities the recent steps of initiating research and maintaining contact with the hunting fraternity are timely. In addition, areas such as breeding sites are being subjected to management practices by agreement with land owners or by land acquisition.

5.3.5 Pollution and contaminants

Land uses as diverse as mining, tourism, urbanisation, and agriculture all bring a threat of water pollution. In the past pollution from mining has attracted a great deal of attention with the example of Rum Jungle mine often quoted (Finlayson et al 1988). The Ranger uranium mine has also been the subject of concern over potential pollution in downstream wetland areas. In the event that any water release from this mine did take place a strict testing and monitoring procedure has been developed (Humphrey & Pidgeon 1995). Unlike the situation that formerly existed at Rum Jungle, uranium mining in the Alligator Rivers Region is subject to a very strict regulatory regime. At a number of other mine sites across the northern region there are problems with acid drainage which may impact on adjacent areas.

Pesticides and fertilisers are used extensively in agricultural projects in the NT (eg Douglas-Daly River catchment) as they are elsewhere. No information is available on their impact on NT wetlands. Expanded horticulture and irrigated cropping could increase the extent of pollution from agricultural chemicals. The expansion of the Ord River irrigation system is of prime concern, especially given past experiences in this region. Weed control on coastal wetlands in the northern region has attracted a large amount of support, yet specific risk assessments and ecotoxicological testing have not generally taken place. In one such assessment in Kakadu it was found that spraying salvinia with a kerosene and surfactant mix (AF100) was not detrimental (Finlayson et al 1994b).

Chemical pollution from sunscreens, soaps and insect repellents used by swimmers may become a problem in the small permanent waterholes of the West MacDonnell Ranges and areas such as Kakadu and Litchfield National Parks. An initial and limited assessment of such problems at a popular plunge pool in Kakadu did not reveal any detrimental effects, although further investigations were recommended (Rippon et al 1994). The problem of fuel spillage from tourist boats should also not be ignored.

Lead poisoning of waterfowl from ingested shotgun pellets is a problem at hunting reserves in the northern region (Whitehead & Tschirner 1991). In some areas where lead poisoning is known to occur, or high lead densities have been recorded, restrictions on the use of lead shot has been implemented. The use of lead shot has been prohibited at two sites: Howard Springs Hunting Reserve and Lambells Lagoon. Conditions of permit to hunt in these reserves requires the use of steel or bismuth shot. A five-year program to entirely phase out lead shot for waterfowl hunting is being developed for the NT, following consultation with affected groups (ANZECC 1996).

Salinity is a major concern in the Top End coastal wetlands; saltwater intrusion from the breakdown of natural levees on floodplains is a threat to freshwater systems (Woodroffe et al 1985a, Jonauskas 1996). It is suspected that feral animals may have contributed to these events, but it is equally argued that they are caused by natural processes that are being exacerbated by human activities that include climate change. Bayliss et al (1995) consider that many of the coastal wetlands are under threat from saline intrusion which may well be a natural process and one which will certainly be exacerbated by any sea level rise in association with the Greenhouse Effect. The current extensive salinisation problems on the Mary River floodplain have received a lot of attention in recent years, with large and small barrages being constructed in an attempt to halt (or merely delay) this intrusion (see papers in Jonauskas 1996).

5.3.6 Water regime and physical modification

Water regulation and physical modification of wetlands in the NT occur, but not to the same extent as in eastern Australia (Gehrke 1995). Small barrages and dams are being constructed, but at this stage these are not considered to be excessively detrimental to processes such as water flow and fish migration etc. The exception is the increasing tendency to construct ponded pastures on the coastal floodplains where there is potential conflict with fisheries interests (Griffin 1995, 1996, Julius 1996).

There has been little clearing and draining of wetlands in the NT other than areas of mangrove in the Darwin region. The clearing of mangroves for port, industrial and/or residential purposes has aroused a lot of controversy in Darwin already. Dredging operations could affect the water regime of wetlands nearby and even further afield. Sand mining within stream beds can affect both the local environment and also the maintenance of off-shore shoals.

Currently no cropping occurs in any NT wetland although the proposed extension of the Ord River Irrigation Area raise concerns over water logging, sedimentation and discharges of water that could well be nutrient enriched and/or polluted. It is believed that cotton and sugar cane will be the predominate crops in the new areas. The development of irrigation channels could see a proliferation of vigorously growing plants. In floodplain environments such aquatic weeds can reduce the mean velocity and conveyance capacity of channels by up to 50% (Lukacs 1995).

6 Ecological linkages between wetlands

Whilst there are obvious physical and biological links between contiguous wetlands in the coastal or northern zone of the NT the nature of these are not well known. Even less is known about the nature of linkages between the intermittent and episodic wetlands of the drier regions of the NT. Some links are apparent, but these are not empirically understood. The level of interaction between catchments is obviously important for at least some species and management planning should be conducted with this in mind. For this to occur an integrated approach to wetland management is required.

6.1 Physical linkages

It has proved extremely difficult to separate NT wetlands into discrete categories (see above), as in many locations a number of wetland habitats are found (see, for example, Fleming

1993, Jaensch 1994). In many instances the wetlands form almost continuous systems or large interconnected complexes. Examples are the mangroves along the coast, the freshwater floodplains adjacent to the mangroves and salt flats, and the coolibah-channel complexes in the central region of the NT.

The physical linkages between wetlands are subject to temporal variation dependent, to a large degree, on the water regime and the extent of flooding. During the Wet season the low levees (20–50 cm high) that separate the coastal floodplains, for example, are awash with floodwaters. If the freshwater floods coincide with high tides in the rivers the floodwaters will spill out through subsidiary drainage channels that connect to adjacent swamps and plains (CM Finlayson pers obs). Similarly, the inland seasonal and intermittent wetlands can be connected during years of exceptional flooding.

Whilst the hydrological connection between many wetlands has been observed on numerous occasions there is very little direct measurement of the spatial and temporal extent. Even less is understood about the groundwater linkages. The vital processes that underpin the functions and production of these wetlands are similarly not well investigated. Without greater understanding of the water regimes of these areas we can not begin to understand the ecological importance of the linkages provided by flooding, whether seasonally, intermittently or episodically. It is clear, however, that many wetlands are linked and can not therefore be managed in isolation.

6.2 Ecological linkages

Some measure of the ecological linkages can be shown by considering the distribution and movement of the biota, especially some of the migratory birds and fish. The best known migratory waterbird is the magpie goose (*Anseranas semipalmata*). Extensive surveys (Morton et al 1990a, Bayliss & Yeomans 1990) have identified the seasonal and annual mobility of this species and, hence, its reliance on geographically dispersed wetlands. To sustain this species several large wetlands fed by erratic rainfalls in separate catchments may be needed. The Mary River and Alligator Rivers provide a good example of the need to maintain wetlands in different catchments to support both Wet season breeding and Dry season feeding habitats for several millions of birds. Jaensch (1994) and Jaensch & Bellchambers (1996) point out that wetlands in the semi-arid zone also support populations of breeding magpie geese and may be extremely important in some years.

Migratory shorebirds also demonstrate the linkages that exist between wetlands, this time at a continental and international scale (Jaensch et al 1995, Watkins 1993). Conservation programs for such species require management of wetlands across their entire migratory range. Such linkages are recognised in the bilateral bird agreements that Australia has signed with both Japan (JAMBA) and China (CAMBA).

Fish migration between habitats is a well known phenomena, but except for barramundi (*Lates calcarifer*) (Griffin 1985, 1987, 1995) and other freshwater species in the Alligator Rivers Region (Bishop & Forbes 1986, Bishop et al 1986, 1990, 1995) it has not been well researched in the NT. Griffin (1995) makes the point that evaluation of the importance of different wetland habitats to fish is hampered by a lack of detailed surveys of fish migration. Barramundi are known from the coastal waters and rivers, but during the early part of the Wet they also utilise the supra-littoral swamps adjacent to the coast as nurseries. As the Wet season progresses the juveniles move into the large swamps and river floodplains before leaving and migrating upstream as the dry approaches. Other fish species also stage spectacular migrations late in the Wet season as part of a refugia seeking mechanism (Bishop et al 1995). The interactions between species and habitats are complex and not well understood.

From a conservation viewpoint, these linkages indicate that many wetlands in the NT can not be managed independently of each other. Given the widespread nature of bird and fish migration, successful conservation needs to be conducted on a broadscale basis that may extend far beyond the borders of specific nature reserves, even those as large as Kakadu National Park. A suite of sites may need to be placed under conservation management, or general conservation covenants or management agreements imposed across important habitats or wetland complexes regardless of land tenure. These proposals may be controversial, but if the goals of the Conservation Strategy of the Northern Territory are to be achieved a wide range of options will need to be seriously evaluated and accepted by wetland users, owners and managers.

7 Sustainable utilisation of wetlands

In recent years a major international effort has resulted in guidelines for the wise use and conservation of wetlands (Davis 1993). This effort not only reflects a growing international awareness of the value of wetlands, but also an awareness of the alarming rate of wetland loss and degradation (see, for example, Finlayson & Moser 1991, Dugan 1990). Comprehensive information on the extent of wetland loss and degradation in the NT is not available. Further, the reasons for this loss and degradation have not hitherto been adequately assessed, except perhaps for some of the more apparent reasons such as weed invasion (eg Lonsdale et al 1995, Storrs & Julien 1996).

To sustainably utilise the valuable and productive wetland habitats of the NT, priority issues for both management and research attention need to be identified. The research effort should be focussed on issues of direct relevance to current and future sustainable usage of the wetlands. Information from elsewhere can be a valuable starting point in determining how the goal of sustainable utilisation and development of the wetland resource of northern Australia can be achieved, but much more local information is needed to meet these goals in the longer term. Specifically, research that is directly applicable to the climate, soils, hydrology and biota of northern Australia is needed. Further, the values and benefits that we derive from wetlands should be identified and characterised.

7.1 Wetland values and benefits

Wetland functions, products and attributes give wetlands benefits and values that make them important for society (see Dugan 1990 and Davies & Claridge 1993 for a summary of these benefits and values). Benefits and values include tangible returns from wetland products (eg fisheries, grazing, water) and less tangible returns from wetland functions (eg groundwater recharge, flood control, nutrient retention) and attributes (eg biological diversity, cultural heritage). In order to maintain, or even to enhance or restore them, the ecological processes that underpin the products, functions and attributes need to be maintained and the habitats managed in a sustainable manner.

The functions performed by wetlands include water storage, flood mitigation, shoreline stabilisation, groundwater recharge, retention of nutrients and sediment, and stabilisation of local climatic conditions. These functions all occur in NT wetlands, but their relative importance in specific wetlands or wetland complexes has not been ascertained. Similarly, with the exception of barramundi and crab fishing in the coastal floodplains/streams and mangroves respectively (Finlayson et al 1991), the importance of harvestable wetland products has also not been ascertained. The highly productive wetlands have been used for grazing and this value is recognised in both the seasonal coastal and intermittent inland wetlands.

Possibly the most valuable attribute of wetlands in the NT is their biodiversity (see above descriptions). Due to the rainfall variability there is a spatial and temporal patchiness of wetland habitats with idiosyncratic annual variations in vegetation pattern superimposed on underlying patterns dictated by local topography, hydrology or soils (Whitehead et al 1992). This diversity of wetland habitats and the highly seasonal, intermittent or episodic nature of the climate has provided a wealth of productive and abundant species (Finlayson et al 1988). Despite the vast amount of data collected on wetlands (Appendix 2) the real extent of the biodiversity of these habitats is still only poorly known, especially for the ephemeral wetlands in the arid zone. A strategic approach to collecting information on biological diversity is required before this situation will improve.

7.2 Current uses of wetlands

The Northern Territory Government has adopted a policy of multiple land use for wetland management (Fleming 1993). This policy attempts to encourage different land uses and balance these with conservation objectives (ie it is akin to the national policy of ecologically sustainable development). Current uses include: pastoralism, grazing and some horticulture; commercial fishing; tourism and recreation, especially amateur fishing; crocodile egg harvesting; commercial pig harvesting; safari style buffalo hunting; conservation and nature reservation; and traditional subsistence. Land uses are more intensive in the seasonally inundated and very productive wetlands near Darwin in the northern coastal region than in the wetlands of the semi-arid and arid areas.

Broad-scale agriculture in the Northern Teritory has not been overly successful with the failed rice developments being one of the better known examples (Mollah 1982). The potential problems with agricultural development in northern Australia were critically and controversially identified more than two decades ago by Davidson (1972). Agriculture has been constrained by infertile, leached soils, a harsh climate and an abundance of vertebrate and invertebrate pests. Horticulture and large scale cropping are not widespread. Pastoralism has been the major land use and management influence on wetlands in the NT over the past 150 years (approx) of European settlement. A summary of land use in wetlands was presented by Finlayson et al (1988). Major land uses across biogeographical regions in the NT are given in Appendix 4.

Pastoralism has been by far the most extensive land use in the Northern Territory with the Tanami, Western Desert and Simpson Desert being exceptions. The wetland areas are the most nutrient rich and mesic areas and thereby produce the best forage for livestock. There has been much debate on the efficacy of pastoral activities in the arid zone of Australia with the popular conception being that conservation objectives can only be met by the complete removal of grazing (Curry & Hacker 1990, Cadzow 1993, Reid 1994). Under some circumstances grazing could be conducted in concert with conservation (Curry & Hacker 1990).

The tourism industry's contribution to the NT economy in 1993/94 was approximately $600 million and is highly dependent on wildlife and scenic/beauty spots. The reserve system bears the brunt of the pressure of the tourist industry (Woinarski 1992). Tourism and recreation are increasingly important land uses based on natural and cultural values. Morton (1993) and Reid (1994) both see nature based tourism providing further income and employment in the future. The recreational fishing industry is well established, especially in the Top End with barramundi being a favoured species and the Mary and Alligator Rivers being very popular destinations (Julius 1996, Griffin 1996). Commercial fishing also occurs with barramundi and mud crabs being targeted. These species are intimately dependent on coastal wetlands throughout their life cycles.

Under the NT Land Rights legislation Aboriginal people have regained large areas of traditional land. Nearly a half of the NT is either Aboriginal land or under land claim and over 85% of the coastline is now under Aboriginal ownership. There is little information on the ecological condition of Aboriginal land in the NT, however the common perception is that it is largely pristine. This perception fails to take into account the increasingly diverse uses of this land and the existence of feral animals and weeds. Economic activity on Aboriginal land contributes significantly to the NT and Australian economies. All the major mines and on-shore oil and gas wells in the Northern Territory are on Aboriginal land as well as some large scale cattle projects.

Conservation of wetland biota is a particularly important land use and is compatible with multiple uses under an ecologically sustainable development ethic. Passive recreation and even hunting safaris are feasible under clear management guidance and strictures, although the latter may not sit comfortably with some sectors of society. National parks and conservation reserves offer many possibilities that are being exploited and have the potential to expand. However, conservation is and should not be not confined to reserves, a fact recognised under ecological sustainable development policies (ESD) (Commonwealth of Australia 1992).

7.3 Projected uses of wetlands

New commercial uses of wetlands are being developed, such as wildlife utilisation (eg goose and crocodile egg collection), expanded tourism (eg hunting or photographic safaris or cultural and wildlife tours) agriculture and horticulture. However, there is limited experience to draw on as to how to utilise wetlands for these purposes in an ecologically sustainable manner. In the northern region hunting and gathering, commercial utilisation of feral animals, and pastoralism could exacerbate attempts to develop new or alternative land uses.

The potential for further horticulture and cropping of floodplains is periodically considered and there are proposals for the Keep River floodplain to be used as an extension of the Ord River Irrigation Area. Horticulture, particularly exotic fruits sustained by Dry season irrigation is seen to have considerable potential. The Douglas/Daly sub-region is favoured for these developments. Although horticulture is unlikely to be undertaken on wetlands themselves, areas suitable for horticulture often abut wetlands. Environmental issues arising from horticulture could include impacts of irrigation on regional water regimes, and the risk of pollution with herbicides, insecticides or fertilisers. Another major potential conflict between horticulture and the environment is that the magpie goose has developed a taste for exotic fruits (Whitehead 1991) as have flying foxes.

7.4 Current mitigation activities

Over the past decade the Commonwealth has launched and funded several initiatives aimed at better environmental protection, such as endangered species programs, ecologically sustainable development, biodiversity strategy, Decade of Landcare, design of natural areas representative reserve network, Indigenous Protected Areas and the rangelands management strategy. As recent changes to legislation governing pastoral lands indicate (Ledgar 1994), there is a growing concern that wildlife and land and water resources should be managed better than in the past, and that other national goals should not be jeopardised unnecessarily through the continuation of existing patterns of land use (Holmes 1994). Such changes point to the adoption of more holistic management strategies.

The development of such an approach will require effective cooperation between agencies and individuals. A good example of this spirit of cooperation is being seen in the Australian Nature Conservation Agency (ANCA) funded project to produce management plans for 10 important wetlands on Aboriginal land - *The Top End Indigenous Peoples Wetland Program.* The Northern Land Council (NLC) is facilitating the process with assistance from Parks and Wildlife Commission of the Northern Territory (PWCNT), ***eriss*** and the Northern Territory University (NTU). There will undoubtedly be practical benefits for all concerned in terms of access to information and expertise. The program commenced in early 1996 and adopts a strategy of 'total catchment management' coordinated between regions. At the local level the community has control of, and participates in, the planning process and implementation phase of wetlands management (P Bayliss, pers comm).

The NLC has a statutory responsibility to assist Aboriginal landholders in land management in the northern and central regions. The NLC is currently shifting its emphasis from land acquisition to land management activities and to this end it has recently set up a land management unit – *The Caring for Country Unit.* The Caring for Country Unit's proposal to develop an Integrated Regional Environmental for Top End Aboriginal Communities will similarly benefit from close cooperation with the PWCNT. This process is well under way (A Kenyon, pers comm).

Further mitigation programs are being funded by the National Landcare Program, with cooperation of several NT agencies, to assess current/future use and management of four river systems in the Katherine region. The project will help identify key issues, problems and priorities, recognise processes causing degradation, and establish a baseline for use in the long-term monitoring of the condition of these river systems (J Faulks, pers comm). Further, the Arid Lands Environment Centre (ALEC) has received funding from the National Estates Grants Program to conduct a management-oriented study of waterholes in the Alice Springs area (T Mahney, pers comm).

Probably the most ambitious attempt to develop a holistic mitigation process was that undertaken to address the problems on the Mary River wetlands. This process aimed to broaden understanding of the wetlands and their environmental problems and to obtain community-wide acceptance of the drastic nature of the actions that needed to be undertaken to ensure that current land uses would survive. Further, it attempted to put into place a mechanism to obtain consensus about future public and private directions for managing these valuable, but degraded wetlands (Jonauskus 1996).

Other research related to wetland management conducted by PWCNT includes: effects of grazing on wetland areas; effects of fire on wetland vegetation; characterisation of magpie goose brood-rearing areas; factors influencing nesting success of the magpie goose; and identification of sensitive sites (breeding rookeries, roosts and feeding areas) for waterbirds and shorebirds.

8 Management responses

Wetland management can not be done in isolation of catchment or landscape scale management. Thus, highly integrated and inter-disciplinary mechanisms are required to support management responses for wetlands. Policies and legislation must be in place. Staff must be trained and equipped. The knowledge base must be sound and readily available. Above all, sectoral divides must be dismantled and effective cooperation developed between relevant individuals and agencies. The primary goal is to promote better management of wetlands and to prevent further loss and degradation of these natural resources.

8.1 Major issues

The above descriptions of major wetland types and, in particular, threats to these wetlands have identified a number of major generic strategic issues that should be addressed if successful management practices are to be implemented to maintain the ecological character of the rich wetland resource of the NT. These strategic issues are presented in table 3 in the context of the key words associated with the specific objectives agreed to for the Conservation Strategy for the Northern Territory (Northern Territory Government 1994).

Table 3 Strategic issues for wetland conservation in the NT expressed within the context of the specific objectives of the Conservation Strategy for the Northern Territory

Conservation strategy objective	Strategic issues for wetland conservation
Understanding	• Develop and maintain a comprehensive inventory database for all wetlands, including protocols to ensure it is updated at regular intervals
	• Characterise and quantify the importance of the physical and ecological interactions and linkages that occur between wetlands
	• Characterise the processes that maintain the ecological character and values and quantify the importance of ecological benefits of wetlands
Public awareness	• Develop community awareness of the extent, values and benefits of wetlands.
Protection and management	• Implement catchment-wide land use planning processes that encompass wetlands and ensure the maintenance of their ecological character and values and benefits
	• Enhance the reservation and management of wetlands within a systematically developed protected areas network that is representative of the diversity of wetland habitats, species and values and benefits
	• Instigate specific management arrangements for wetland conservation and sustainable utilisation regardless of land tenure
	• Enhance the level of control over and planning of grazing activities, especially in the central and southern regions
Monitoring	• Develop and implement monitoring programs that describes the ecological character of wetlands to provide early warning of any potential adverse change.
Restoring	• Assess the extent of ecological degradation caused by specific pest species and develop appropriate control measures based on rigorous risk assessment.
	• Undertake immediate control measures for effective management of salinisation and other effects associated with climate change, especially in the northern region.
	• Undertake immediate control measures for effective management of grazing in all wetlands.
Reviewing	• Develop and implement a regular and systematic reporting process on the state of wetlands.

Development of all of the above strategies could severely stretch the finite resources available for conservation and for wetland conservation in particular. However, it is not beyond the imagination to identify various activities within such strategies that could be undertaken in collaboration with other conservation and land management initiatives at both the local and national level. In developing the above list of issues a large emphasis was placed on integrated land use and planning policies. Unless an integrated and multi-sectoral approach is taken it is doubtful that the above strategies could be effectively developed and implemented. Wetland conservation and sustainable use can not be undertaken in isolation of land management and social polices.

8.2 Mitigation processes

Mitigation at a number of levels is necessary. In some instances further research will be necessary and at the same time, specific and immediate management or control tasks will be required. Management decisions are often reactive in the face of urgent or seemingly intractable problems. Thus, the best use of existing information must be the mainstay of management support systems as new and/or superior information is collected or collated and techniques developed and applied.

8.2.1 Recommended future management actions

The main thrust for wetland conservation, especially in the northern region, must be management with the available information, whilst further and strategic research is undertaken. With the nature of current threats there is still time and the opportunity to put adequate management in place, but the time is not unlimited. The management effort will require updating and improvement of the basic inventory databases and increased knowledge of processes and ecological linkages. A number of particular management related activities are described below. Specific strategies are required to address these issues.

Inventory

The biggest obstacle for effective wetland management in the arid and semi-arid regions of the NT is the lack of scientifically documented knowledge and basic data. Wetlands cannot be managed sustainably nor protected from threatening processes, if their value, location or very existence is unknown.

At a generic level, the initial requirement for conservation planning is to identify and map the wetlands. A thorough analysis of the conservation status of NT wetlands can not be done without undertaking a comprehensive mapping exercise. This could be done with existing topographic maps and remote sensing (Johnston & Barson 1993, Jaensch 1994) coupled with the collation of existing (often anecdotal) information. Detailed mapping of wetland vegetation could then be undertaken using aerial photography. Regardless of the techniques adopted, it is critical that mapping and inventory be underpinned by an accepted classification system.

Once information is collected it is essential that it is analysed and stored in an appropriate manner and made available to relevant parties. Relational databases and decision support systems could enhance the value of inventory and survey information by making it readily available to the users and facilitating updating. The existing processes seeking development of integrated data storage and interrogation systems within the PWCNT should be encouraged and applied to wetlands as a matter of priority.

Land use planning

Regional planning that includes a thorough consultative process should be undertaken throughout the NT. Land use and development studies such as that produced for the Gulf Region (Northern Territory Department of Lands and Housing 1991) can act as a sound basis for future land use decisions by establishing an information base, provided information on natural values is enhanced and accorded sufficient weight in the planning process. Such planning will need to take into account global issues such as climate change that will affect more than the coastal wetlands (Bayliss et al 1995). Emphasis must be placed on the involvement of land owners.

Representation of wetlands within nature reserves

A representative system of nature reserves based on a systematic assessment of conservation needs and significant and unique features is required. This is especially so for much of the arid southern section of the NT. Given the history of widescale vegetation change in this area, there is no legitimate place for stock-grazing in such reserves. Further, given the incompleteness of our understanding of arid zone ecosystems and processes, it would be prudent to set aside large, representative conservation areas as 'benchmarks' with appropriate and even a diversity of management covenants. Under some circumstances and management regimes, grazing may be compatible with the long-term conservation of many species, but especially significant areas will warrant complete protection from grazing (Reid & Fleming 1992).

Off-reserve conservation

Effective conservation of wetlands is unlikely to be achieved within the reserve system alone. Biogeographical regions, ecosystems and species habitats extend beyond the boundaries of reserves. Under the PWCNT's existing multiple land use policies, resource use is incorporated within the conservation management framework.

Conservation outside protected areas cannot be a haphazard affair and may be far more difficult than conventional conservation through reserves. Done properly, off-reserve conservation will most likely be 'education and information-intensive' and require resources for better and more sophisticated levels of management than is required in reserves (Mott & Bridgewater 1992). It is not illogical to think that once we have developed and then implemented integrated approaches to conservation planning, that we will be far closer to implementing multiple use policies that embrace conservation.

Riparian corridors possess an unusually diverse array of species and environmental processes (Bunn et al 1993). Guidelines need to be developed to provide riparian buffer zones especially along major rivers of the northern and central region, ie consideration should be given to issues such as the interaction between pastoral lease boundaries and the water's edge, or other mechanisms for incentives to encourage improved management.

Invasive species

There is no doubt, even if it is not well assessed, that weeds and feral animals have wrought great changes to the ecological character of our wetlands. Directing attention to the agent of such ecological change (ie the pest species) has characterised our approach to pest management and, in some instances, this has been successful (eg salvinia) if not highly successful (eg Asian water buffalo). However, we have not often equally addressed the actual reasons for the problem in the first place; ie what factors really caused a particular species to become a pest?

Preventing the introduction and/or further spread of pest species are obvious strategies and these can be targeted at either the pest themselves or the means of proliferation, or even introduction, if we are considering potential pests. Quarantine and restrictions on trade are needed, but most of the species referred to above are already widely distributed, at least regionally.

Simply addressing the occurrence of the unwanted agent of change after it has arrived and proliferated without also addressing the reasons for the species becoming a pest in the first instance is akin to treating the apparent and not the underlying reasons for wetland loss and degradation (see Hollis 1992, Finlayson 1994, Hollis & Finlayson 1996). The apparent changes are the manifestation of a host of underlying economic and/or resource management/planning decisions. Pest management should also take into account the basic causes of the problem and ensure that these are being addressed at the same time as the pest itself is being attacked.

If the reason for control of a pest species is obvious then it would presumably be relatively simple to demonstrate the cost-benefits. However, perhaps the most insidious cause of pest problems or the extension of problems is the lack of a community sense of responsibility for the problem. In many instances the incentives for action by individuals are very low. If the cost of actions by individuals are too high relative to the returns that could be expected then there is little, if any, incentive.

Grazing

Pastoral grazing causes significant changes to wetland vegetation and, hence, affects native animal species. As indicated by Reid (1994) and Morton et al (1995) there is a need to remove commercial grazing from some parts of the landscape—perhaps as much as 10% of the arid zone region (throughout central Australia) currently grazed. Appropriate compensation for the lessees involved, would have to be negotiated. One solution to the problems caused by grazing is to fence off permanent and near-permanent waterholes to exclude stock. However, these wetlands can be important to the viability of a pastoral enterprise and, therefore, adequate access and/or compensation is required. At the same time, cooperative management structures for other significant wetlands in the region should be pursued through a genuinely consultative process and along the lines of the stewardship model of Morton et al (1995).

Salinisation and climate change

In terms of actual threats to wetlands the specific issue of saline intrusion along the coastal floodplains has been identified as a priority issue along with the more generic issue of pest species. The insidious nature of global scale change has been recognised and many wetlands, especially the coastal ones, are under threat (Bayliss et al 1995). Protection of these habitats will require truly multi-sectoral responses.

Community awareness

Community awareness of the problems caused by, for example, pest species is constantly required. Glossy publications have often been used, but their effectiveness has not been assessed. Much more is needed, but before this is attempted relevant professional advice on the most appropriate means of transferring information is required (eg the role of regional or local newspapers, community radio and television, short video clips). Once various media have been identified the nature of the message and the target audience needs analysis.

A number of messages may be necessary depending on the status of the pest problem. Different messages are required for prevention of entry (eg quarantine or trade bans on particular species), limitation of distribution (eg restrictions on entry or transfer of machinery, vigilance and reporting), control requirements (eg release of biological control organisms, widescale spraying or shooting, integration of methods and planning) and rehabilitation of degraded areas (eg the rationale and techniques). The dangers to both the local and national environment and economy should be explained with simple and succinct messages that are based on technical, economic and community attitude analyses.

At a more general level personal contact and extension activities are essential. This is an area that is not often within the expertise of research or field control staff; relevant expertise and professionalism is needed to sell the messages to the identified target audience. Awareness covers all sectors of society (including government officials and resource users) and cuts across all the technical issues covered below. Case studies provide good material for increasing public awareness.

8.3 Priorities for protection

As discussed above, the priority for protection is considered to be the wetland habitats of the central and southern regions of the NT. This is not discussed further. Other priorities are covered by the more generic treatment of threats and especially habitats invaded by pest species, such as the coastal floodplains. It is stressed, however, that protection is but one mechanism for ensuring conservation and should not be undertaken in isolation of other mechanisms that contribute to ESD.

8.4 Legislative and administrative structures

Legislation may be required to enforce aspects of wetland management (eg hunting regulations along with prescribed penalties). Specific punitive measures may be warranted, but there is an increasing international trend to look for more positive use of legislative (and even taxation) mechanisms to encourage land owners and users to adopt sustainable practices. We have not attempted to identify specific legislation or other prescriptive polices, but it is pointed out that these may be necessary. In some instances they could even prescribe mandatory actions.

Legislative and administrative structures that can promote and develop conservation on an integrated basis are seen as a priority. Conservation does not stop at reserve boundaries and is not the sole prerogative of a single agency. Management planning on reserves is essential and should be integrated with adjacent land uses that are themselves governed by agreed principles of ecologically sustainable utilisation. Wetlands are part of much larger landscape units (whether catchments or biogeographical zones) and can not be effectively managed in isolation of these units. Sectorally oriented administrative structures may be unavoidable, but this is not an excuse for sectoral management. Inter-agency and/or local community consultation, such as has been developed through Landcare initiatives (eg on the lower Mary River), should be enhanced and, at appropriate times, critically audited.

When considering legislative means for conservation planning it would be extremely helpful if all legislation pertaining to wetlands was reviewed and assessed with regard to relevance, overlap and contradiction. A thorough review process would provide an opportunity to develop integrated planning structures and further enhance transparency of government decisions. Conservation planning has, in recent years, taken more and more notice of the need to involve local communities in the decision making processes. The legislative means to ensure that this happens could not only include access to consultative mechanisms, but also the right to 'make the decisions' through appropriate representation on committees etc that influence or guide the decision-making processes. As stated in the introduction to this overview, the development of a strategy for wetland management can only be truly effective if achieved through a process of intra-governmental and community consultation.

Appendixes

Appendix 1

Plant species used to produce the distribution maps for the general wetland categories shown in figures 5–8. The species lists were derived from Jaensch (1994)

Riverine floodplains	Seasonal/intermittent freshwater lakes	Seasonal/intermittent freshwater ponds/marshes	Freshwater swamps
Aeschynomene spp	*Astrebla auricomum*	*Aeschynomene* spp	*Aeschynomene* spp
Eleocharis spp	*Chenopodium auricomum*	*Barringtonia acutangula*	*Chenopodium auricomum*
Excoecarina parviflora	*Cyperus bifax*	*Cynodon dactylon*	*Eleocharis* spp
Fimbristylis spp	*Cyperus vaginatus*	*Diplachne parviflora*	*Eucalyptus microtheca*
Hymenachne acutigluma	*Diplachne parviflora*	*Eleocharis* spp	*Eulalia aurea*
Imperata cylindrica	*Eleocharis pallens*	*Eucalyptus camaldulensis*	*Excoecarina parviflora*
Ipomoea spp	*Eucalyptus aff. aspera*	*Eulalia aurea*	*Marsilea* sp.
Ischaemum rugosum	*Eucalyptus camaldulensis*	*Lophostemon grandiflorus*	*Melaleuca cajaputi*
Leersia hexandra	*Eucalyptus microtheca*	*Nymphoides* sp.	*Melaleuca leucadendra*
Malachra fasciata	*Eucalyptus papuana*	*Ophiuros exultatus*	*Melaleuca viridiflora*
Melaleuca leucadendra	*Muehlenbaeckia cunninghamii*	*Oryza australiensis*	*Muehlenbaeckia cunninghamii*
Muehlenbaeckia cunninghamii	*Panicum* spp	*Oryza rufipogon*	*Nymphaea spp*
Nelumbo nucifera	*Parkinsonia aculeata*	*Pseudoraphis spinescens*	*Oryza australiensis*
Oryza rufipogon	*Psoralea cinerea*	*Sesbania* spp	*Oryza rufipogon*
Panicum spp	*Sesbania* spp	*Panicum* spp	*Pseudoraphis spinescens*
Phragmites karka	*Sporobolus mitchelli*	*Xerochloa imberbis*	*Sesbania cannabina*
Pseudoraphis spinescens	*Sporobolus virginicus*		*Sesbania sesbans*
Sesbania spp			

Appendix 2

A list of datasets, digital and non-digital, that pertain to Northern Territory wetlands. The datasets have been grouped into four sections: Pan Territory, Northern Region, Central Region and Southern Region.

Dataset	Custodian	Purpose	Nature	Status	Access
Pan-Territory					
Biogeographic regions of the NT	DLPE Dave Howe	To identify the major ecosystems of the NT for defining priority natural resource management programs	Polygons on maps defining geographic, landform and climatic combinations	Active	Open
Conservation and Recreation Values Register (CRVR)	PWCNT Libby Sterling	As a record of information on the conservation and recreation attributes of land in the NT	A register of conservation and recreation uses and values for locations in the NT	Active	Restricted
Environmental Domain Classification for the NT	PWCNT Angus Duguid	To explore the use of terrain and climate data to define biophysically homogenous regions or domains within the NT using a raster GIS	The classification was done by CRES under contract to the CCNT	Closed	Open
Fauna - Arachnids	NT Museum Graham Brown	To catalogue the NT Museum's collection of spiders, mites, etc	A catalogue of the arachnid specimens including taxonomic and collection details	Active	Restricted
Fauna - Barramundi database	DPIF Roland Griffin	For the management of the commercial and recreational barramundi fisheries of the NT	Length, frequency, reproduction, growth, recruitment, migration, sex and composition data linked to location of capture	Active	Restricted
Fauna - Biological Records Scheme	PWCNT John Woinarski	As a fauna database for observation records within the NT	Taxonomic and collection data for observed mammals, birds, reptiles, frogs. Includes presence/absence information, date, time and location (to nearest degree or km) of sighting	Active	Open
Fauna - Birds	NT Museum Paul Horner	To catalogue the NT Museum's collection of bird specimens	A catalogue of bird specimens including taxonomic and collection details	Active	Restricted
Fauna - Birds, coastal raptor nesting sites	PWCNT Ray Chatto	To document coast and island nesting sites for sea eagles, ospreys, brahminy kites and jabiru	Audio tapes of aerial survey counts and ground truthing	Active	Restricted

Appendix 2 (cont'd)

Dataset	Custodian	Purpose	Nature	Status	Access
Fauna - Birds, waders significant sites of the coast and Islands of the NT	PWCNT Ray Chatto	To locate and document significant wading bird feeding, breeding and roosting sites in the NT	Audio tapes of aerial survey counts, ground truthing, distribution status of birds and sites	Active	Restricted
Fauna - Crocodile (saltwater) nests	PWCNT/WMI Grahame Webb	Monitoring and management of saltwater crocodiles	Egg and nest characteristics and locations	Active	Restricted
Fauna - Crocodile (saltwater) surveys	PWCNT/WMI Grahame Webb	Population monitoring and management of saltwater crocodiles	Spotlight and helicopter count data in different river systems	Active	Restricted
Fauna - Crocodile (freshwater) surveys	PWCNT/WMI Grahame Webb	Population monitoring and management of freshwater crocodiles	Spotlight and helicopter count data in different river systems	Active	Restricted
Fauna - Crocodile (saltwater) problem individuals	PWCNT/WMI Grahame Webb	Management of saltwater crocodiles	Size and location data of problem saltwater crocodile captures	Active	Restricted
Fauna - Crocodile (freshwater) problem individuals	PWCNT/WMI Grahame Webb	Management of freshwater crocodiles	Size and location data of problem freshwater crocodile captures	Active	Restricted
Fauna - Crocodile (saltwater) marked individuals in the wild	PWCNT/WMI Grahame Webb	Management and research of saltwater crocodiles	All marked saltwater crocodiles in the wild; location, size, sex, etc	Active	Restricted
Fauna - Crocodiles (freshwater) marked individuals in the wild	PWCNT/WMI Grahame Webb	Management and research of freshwater crocodiles	All marked freshwater crocodiles in the wild; location, size, sex, etc	Active	Restricted
Fauna - Crocodiles (saltwater) attacks on humans	PWCNT/WMI Grahame Webb	Management of saltwater crocodiles	Saltwater crocodile attacks on humans since 1971	Active	Restricted

Appendix 2 (cont'd)

Dataset	Custodian	Purpose	Nature	Status	Access
Fauna - Dugong and sea turtle dataset	PWCNT Keith Saalfeld	Monitoring and management of dugong and sea turtle in NT waters	Count data by observations recorded on transect based aerial surveys	Active	Open
Fauna - Fishstat	NT Museum Helen Larson	To catalogue fish localities in the NT	A catalogue of fish locality data	Active	Restricted
Fauna - Fishspec	NT Museum Helen Larson	To catalogue the NT Museum's collection of fish specimens	A catalogue of fish specimens including taxonomic and collection details	Active	Restricted
Fauna - Frogs	University of Adelaide Mike Tyler	To determine the species of frogs that occur in the NT, their biology, physico-chemical features of their habitat and biogeographic interpretation	Territory wide transect information with occasional short-term studies. Database largely exists as written records with published information. Data span the last 3 decades	Active	Open
Fauna - Herps	NT Museum Paul Horner	To catalogue the NT Museum's collection of reptile and amphibia specimens	A catalogue of reptile and amphibia specimens including taxonomic and collection details	Active	Restricted
Fauna - Insects	NT Museum Graham Brown	To catalogue the NT Museum's collection of insect type specimens	A catalogue of insect type specimens including taxonomic and collection details	Active	Restricted
Fauna - Invertebrate (freshwater) database	University of Adelaide Mike Tyler	To obtain information on freshwater invertebrate communities of the NT	Territory wide transect information with occasional short-term studies. Database largely exists as written records with some published information. Data span the last 3 decades	Active	Open
Fauna - Myriapods	NT Museum Graham Brown	To catalogue the NT Museum's collection of myriapod specimens	A catalogue of myriapod specimens including taxonomic and collection details	Active	Restricted
Fauna - Macroinvertebrates - Monitoring River Health Initiative NT	PAWA Jane Suggit	To characterise Top End rivers and creeks using macroinvertebrate data as part of an Australia wide program to assess the health of the nation's rivers	A database of macroinvertebrate fauna, water quality and river characteristics from 120 sites across the NT north of 18°S	Active	Open
Fauna - Mammals	NT Museum Paul Horner	To catalogue the NT Museum's collection of mammal specimens	A catalogue of mammal specimens including taxonomic and collection details	Active	Restricted

Appendix 2 (cont'd)

Dataset	Custodian	Purpose	Nature	Status	Access
Fauna - NT Wildlife Atlas	PWCNT Owen Price	To identify significant areas where rare or threatened animals live or have been recorded. To generate fauna bioregions and as a research tool to investigate the distribution of species	Point records of species observations, including mammals, birds, reptiles and frogs. Includes NT data from all state and territory museums, CSIRO's main collection in Canberra, the RAOU's bird atlas and EIS fauna surveys	Active	Restricted
Fauna - Specimen Records Scheme	PWCNT John Woinarski	As a fauna database for observation records within the NT. Similar to the Biological Records Scheme but includes more information	Taxonomic and collection data including location, date and time of observation. Also morphology, breeding condition etc. Data collected by trapping. Some specimens forwarded to the NT museum, remainder released	Active	Open
Fauna - Turtle (marine) breeding sites NT	PWCNT Ray Chatto	To locate and identify marine turtle breeding sites, breeding species and timing	Audio tapes of aerial surveys with ground truthing	Active	Restricted
Fauna - Wildlife Conservation Status List (NT)	PWCNT Owen Price	To record the list of species seen in the NT, their relative abundancy and conservation status	A summary of the NT Wildlife Atlas, A list of species observed (1 record per species), the ANZECC conservation status and the number of reserves in which that species has been observed	Active	Restricted
Fauna - Wildlife Reserves List (NT)	PWCNT Owen Price	To record the wildlife (mammals, frogs, birds, reptiles) present in NT parks and reserves	A list of species recorded from each park by sighting, surveys and data from the NT Wildlife Atlas	Active	Restricted
Flora - NT Herbarium Dataset	PWCNT Clyde Dunlop	To document the distribution and habitat notes of NT flora	Point data, field observations, species names, collection dates, phenological data, specimens	Active	Restricted
Flora - Vegetation survey of the NT	DLPE Peter Brocklehurst	To provide a systematic standardised vegetation map of the NT. To obtain an ecological perspective over the NT	Floristic and environmental plot data over all regions in the NT. Data includes a digital map, database and a report with a published map	Closed	Open
Hydrography - Surface water hydrographic dataset	PAWA Robert Masters	To determine the quantities of water in NT surface waters (river systems, estuaries)	Tidal and river heights, flow measurements. Approx. 100 gauging stations currently in operation	Active	Open
Hydrography - Ground water hydrographic dataset	PAWA Robert Masters	To determine the quantities of water in NT ground water systems	Bore flows and depth measurements. Approx. 30,000 bores NT wide	Active	Open

Appendix 2 (cont'd)

Dataset	Custodian	Purpose	Nature	Status	Access
Hydrology - Heavy metals in fresh-water ecosystems of the NT	NTU David Parry	To establish baseline levels of heavy metals in NT freshwater ecosystems, minesite monitoring and research	Point site data for cadmium, lead, zinc, copper, mercury, arsenic, manganese, etc	Active	Open
Hydrology - Water quality dataset - NT	PAWA John Childs	To catalogue the characteristics of all naturally occurring ground and surface waters of the NT. To store water data for ongoing resource management	Records of a series of physical, chemical and bacterial parameters	Active	Open
Land Resources - Monitoring sites	DLPE Blair Woods	A record of monitoring sites in the NT where scientific data has been collected including research trials and flora and fauna surveys	Location and area of sites, description of data collected, whether data is digital or hard copy, accessibility, reasons for establishing site	Active	Restricted
Park estate register - NT	PWCNT Libby Sterling	A record of tenure history, ownership and classification of parks and reserves in the NT	Details of park area, portion numbers, land claim status, mining reserves, ownership, declaration and gazettal dates and IUCN status	Active	Open
Parks and Wildlife Commission data directory	PWCNT Ann Fuchs	To record all known datasets held by the Commission, both digital and non-digital	Metadata about data	Active	Open
Weather records	Bureau of Meteorology Climate Consulting Services Geoff Smith	To provide a NT wide record of climatic variables	Long-term written or electronic databases for various sites throughout the NT. Includes temperature, rainfall, humidity etc	Active	Open
Weeds - Management of noxious aquatic weeds	DPIF Ian Miller	To protect the aquatic environment from the effects of noxious aquatic weeds	Details of physical, chemical and biological control	Active	Open
Weeds - Noxious weeds recording system	DPIF Graham Schulz	To record localities of noxious weeds in the NT and detail control action undertaken	Weed surveys and control. Ground and aerial surveys, aerial photos, public reports, chemical, mechanical biological and ecological control	Active	Restricted

Appendix 2 (cont'd)

Northern Region

Dataset	Custodian	Purpose	Nature	Status	Access
Fauna - Crocodiles (saltwater) in Kakadu National Park	ANCA - Kakadu Garry Lindner	To monitor the status of saltwater crocodile populations in the waterways of Kakadu	Spotlight surveys, plus data on trapped and marked individuals in Wildman, West Alligator, South Alligator and East Alligator Rivers	Active	Open
Fauna - Fish biological and ecological information, Alligator Rivers Region	ERISS Bob Pidgeon	To provide information on the biology and ecology of freshwater fish to assist with the development of environmental management procedures	Data derived from measurements of fish and habitat parameters during surveys in 1978 to 1979	Closed	Restricted
Fauna - Fish community structures, upper South Alligator River	ERISS Bob Pidgeon	Monitoring of mining impact from proposed Coronation Hill Mine	Point records of fish species abundance using visual counts from a canoe. 10 sites in early Dry season for 3 years	Closed	Restricted
Fauna - Fish community structures, near Nabarlek Mine, Alligator Rivers Region	ERISS Bob Pidgeon	Assessment of impact of mine operation on aquatic ecosystem and effectiveness of rehabilitation works	Point records of fish species abundance using creekside visual counting procedure in Cooper and Gadjarigamundah Creeks. 4 counts at monthly intervals, Mid-wet/Early-dry season	Active	Restricted
Fauna - Fish communities in lowland billabongs, Alligator Rivers Region	ERISS Bob Pidgeon	To develop biological monitoring protocols to assess environmental health through describing natural variation of fish community structure	Point records of fish species abundance using 'pop-net' sampling and 'visual counting' techniques. 10 billabongs are sampled annually. Broad environmental variables (water quality and vegetation structure) are also recorded	Active	Restricted
Fauna - Fish distribution and abundance in Gulungal Creek, Alligator Rivers Region	ERISS Bob Pidgeon	Describe seasonal changes in patterns of fish distribution and examine the influence of hydrology on the dynamics of fish communities (potential spatial control for migration data from Magela Creek)	Point records of fish species abundance using visual counts made by diving. 10 sites along the creek at monthly intervals from 1980 to 1988	Closed	Restricted

Appendix 2 (cont'd)

Dataset	Custodian	Purpose	Nature	Status	Access
Fauna - Fish gillnet surveys in lowland billabongs of Magela Creek, Alligator Rivers Region	ERISS Bob Pidgeon	Provide information on the dynamics of fish communities and develop a monitoring system for detecting changes resulting from mining	Point records of fish species abundance of biomass using multi-panel gillnets. 10 sites (5 times per year)	Closed	Open
Fauna - Fish migration, Alligator Rivers Region	ERISS Bob Pidgeon	To describe fish migration patterns in Magela Creek and migration pattern response to environmental factors	Point records of Up-stream / Down-stream migration at sites on Magela and Nourlangie Creeks	Active	Restricted
Fauna - Insects of Darwin Harbour mangroves	NTU Richard Noske	To determine diversity, seasonality and abundance of insects in the mangroves of Darwin Harbour	Interception, malaise, window and sticky traps. 2 of each at 3 sites in 3 mangrove zones. Also some branch clipping sampling	Closed	Restricted
Fauna - Lead shot levels	PWCNT Peter Whitehead	To assess the risk of lead poisoning in water fowl and other species from lead shot. Data available for Howard Swamp, Harrison Dam and Lambell's Lagoon NT	Sediment cores, counts of lead shot, grit and food in cores. Samples from birds are tested for presence of lead in gizzards, bone, muscles and liver	Closed	Open
Fauna - Macroinvertebrate (benthic) communities, upper South Alligator River	ERISS Chris Humphrey	Initially instituted in 1987 to assess possible effects of mining at Coronation Hill and continued in 1991 as part of the national Monitoring River Health Initiative	Site data of benthic macroinvertebrate communities in riffle substrates Also includes data on physico/chemistry, habitat structure and hydrology. Contains nearly 10 years of continuous data	Active	Restricted
Fauna - Magpie Geese dataset	PWCNT Keith Saalfeld	To monitor the Magpie Goose population in the Top End wetlands and to detect changing trends in population structure and distribution	Count data by observations recorded on transect based aerial surveys	Active	Open
Fauna - Magpie Geese population in the Top End - status	PWCNT Peter Whitehead	To monitor the population of Magpie Geese in the Top End of the NT	Count and banding data. Systematic aerial surveys of distribution and abundance allowing comparisons over time. Data on reproductive activity, numbers of nests. Data supplemented by radio tracking. Data was collected for all Top End wetlands in 1983-84. Data was only collected from, Murganella to the Moil Floodplain from 1986-89	Closed	Open

Appendix 2 (cont'd)

Dataset	Custodian	Purpose	Nature	Status	Access
Fauna - Magpie Geese - vegetation associated with nesting sites	PWCNT Peter Whitehead	To characterise the sites used by Magpie Geese during the reproductive period. For management and retention of sites. To assess the effect of grazing on Magpie Geese habitats	Floristic descriptions of each nest and brood site. Broad descriptions of dominant vegetation types in the vicinity. Transect based floristic and broad habitat descriptions on brood and nesting sites	Active	Open
Fauna - Oenpelli Floodplain	CSIRO TERC Garry Cook	To monitor environmental effects of mimosa control	Count data by observations recorded on individual sites 1991-95	Active	Open
Fauna - Significant waterbird sites for the NT flood plains	PWCNT Ray Chatto	To locate and document significant coastal waterbird breeding, feeding and roosting sites	Audio tapes of aerial survey counts, ground truthing, distribution status of birds and sites	Active	Restricted
Fauna - Significant seabird sites of the NT coastal flood plains	PWCNT Ray Chatto	To locate and document significant seabird breeding and roosting sites and breeding times in the NT	Audio tapes of aerial survey counts, ground truthing, distribution status of birds and sites	Active	Restricted
Feral animal survey - Top End 1981	PWCNT Dave Berman	To determine the numbers of buffalo and other large vertebrates in the Top End (North of 15°S) of the NT	Feral animal population counts by aerial transects 20 km apart at altitude of 250 ft	Closed	Open
Feral animal survey - Top End 1985	PWCNT Keith Saalfeld	To determine feral animal abundance in the Top End of the NT	Count data by observations recorded on transect based aerial surveys	Closed	Open
Feral animal survey - Bali Cattle (Banteng)	PWCNT Keith Saalfeld	To monitor banteng numbers and to provide management advice for the banteng population on Coburg Peninsula, NT	Count data by observations recorded on transect based aerial surveys	Closed	Open
Flora - Cattle grazing study - Mary River	PWCNT Dave Liddle	Long term monitoring of cattle and buffalo grazing on coastal flood plains	Three different vegetation types with grazed and ungrazed plots. Four replicates in each vegetation type. 12 sites	Active	Restricted
Flora - Melaleuca survey of the NT 1990	DLPE Peter Brocklehurst	To determine the community distribution, description and potential logging volumes of Melaleuca species in the NT north of 18°S	Environmental and floristic data	Closed	Restricted
Flora - Oenpelli Floodplain	CSIRO TERC Garry Cook	To monitor the environmental effects of mimosa control	Cover estimates by species recorded on individual sites 1991–93	Closed	Open

Appendix 2 (cont'd)

Dataset	Custodian	Purpose	Nature	Status	Access
Flora - Vegetation communities of Arafura Swamp	DLPE Peter Brocklehurst	To provide vegetation data for the Arafura Swamp region of the NT	Floristic and environmental data	Closed	Restricted
Flora - Wetlands floristic survey	DLPE Peter Brocklehurst	An inventory of flora occurring in coastal region wetlands of the NT	Grid based survey with 2.5 km gridlines. Data includes floristic survey, pH, salinity	Closed	Open
Marine bioregionalisation database	PWCNT Laurie Ferns	To formulate biophysical and bioregional attributes for the entire NT coastline	A collation of datasets relevant to the NT marine environment including; sea surface temperatures, salinity, oxygen, nitrates, phosphates, tidal ranges etc	Active	Restricted
Saline intrusion - Lower Mary River Catchment	DLPE Paul Frazier	To monitor the effect of barrage construction on saline intrusion	Landsat 5 thematic mapper, 30 metre pixals	Active	Restricted
Weeds - *Mimosa pigra* - impacts of biological control agents	CSIRO TERC Naomi Rea	To evaluate the establishment and spread of biological control agents for mimosa	Observations of impact and occurrence of agents on the Adelaide River Floodplain. From 1989	Active	Open
Weeds - *Mimosa pigra* in Kakadu National Park	ANCA Kakadu Garry Lindner	To manage *Mimosa pigra* in Kakadu National Park	Point site data of Mimosa incursions with details of control measures undertaken	Active	Open
Weeds - *Mimosa pigra* management	DPIF Ian Miller	To protect industry and the environment from the effects of *Mimosa pigra*. To contain mimosa in the NT and prevent its further spread	Details of chemical, biological, mechanical and ecological control. Assistance to landholders	Active	Open
Weeds - *Mimosa pigra* (Oenpelli)	PWCNT Kate Sanford-Readhead	To evaluate the *Mimosa pigra* control program on the Oenpelli Floodplain	Field observations of herbicide application	Closed	Restricted
Weeds - *Mimosa pigra* on CCNT estate	PWCNT Kate Sanford-Readhead	Strategic planning of *Mimosa pigra* control program including a record of herbicide use on the CCNT's estate	Field observations of herbicide application on CCNT land in the Adelaide and Mary River Floodplains	Active	Restricted

Appendix 2 (cont'd)

Dataset	Custodian	Purpose	Nature	Status	Access
Weeds - *Mimosa pigra* research data	DPIF Ian Miller	To develop integrated management plans for the control of *Mimosa pigra*	Biological studies, quarantine, rearing, release, and monitoring of biological agents. Herbicide efficacy trials. Ecological control by fire, competitive pastures	Active	Restricted
Weeds - *Mimosa pigra* seed production	CSIRO TERC Naomi Rea	To evaluate the impact of control agents on mimosa seed production	Observations of seed production by mimosa on the Adelaide and Finniss River Floodplains. From 1991	Active	Open
Weeds - *Salvinia molesta* in Kakadu National Park	ANCA Kakadu Buck Salau	To manage the *Salvinia molesta* infestations in Kakadu National Park	Monthly mapping of salvinia plus counts of weevil biological agent and assessment of damage	Active	Open
Wetlands - semi urban/rural status	PWCNT Peter Whitehead	To assess the importance of wetlands to regional populations of waterbirds. To assess the affects of urban sprawl on wetland condition	Floristic descriptions of wetlands and counts of waterbirds over time	Active	Open
Central Region					
Fauna - Waterbird usage of the wetlands of the sub-humid tropics of the NT	PWCNT Peter Whitehead	To provide information on the distribution, abundance and breeding of waterbirds	Point data from ground and boat surveys	Active	Restricted
Feral animal survey - Gulf Region 1984	PWCNT Dave Berman	To estimate feral horse numbers and numbers of other large vertebrates in the NT Gulf Region	East west aerial transects 20 km apart at 250 ft altitude	Closed	Open
Feral animal survey - Victoria River District 1981	PWCNT Dave Berman	To estimate the number of feral donkeys and other large vertebrates in the Victoria River District of the NT	Feral animal population counts by aerial transect	Closed	Open
Feral animal survey - Victoria River District 1992	PWCNT Keith Saalfeld	As an aid to the management of feral animals in the Victoria River District of the NT	Horse and donkey count data by observations recorded on transect based aerial surveys	Active	Open

Appendix 2 **(cont'd)**

Dataset	Custodian	Purpose	Nature	Status	Access
Flora - Longreach waterhole vegetation survey and mapping	PWCNT Brenda Pitts	To provide data for the conservation management of a protected area	Point site data for flora including species abundance and distribution, floristics, weeds, rare species and locations	Closed	Restricted
Flora - Nomenclature, distribution and conservation status	PWCNT Dave Albrecht	Store information on the nomenclature, distribution and reservation status of plants in the arid zone and Mitchell grass plains	Fields include family, native or introduced, name, Barlow region, bioregion, no. reserved and non-reserved occurrences in each bioregion, risk code, relict status, extra NT distribution, interstate distribution for rare taxa. This database is a precursor to a larger database on the biology of the Southern Region	Active	Open
River assessment - Katherine Region 1995- 1997/98	DLPE Wolf Sievers	To provide information on the physical and environmental condition, current/future use and management of 4 river systems (Katherine/Daly, Victoria, Roper and McArthur Rivers) in the Katherine Region to establish a baseline for long-term monitoring of the condition of these rivers	Site data and longitudinal profiles from field/boat surveys and aerial photography/satellite image interpretation. Information will include sub-catchment boundaries; rivers and flood plain features, physical characteristics, vegetation, land use/land tenure, impacts and factors affecting river stability, and flow and water quality information	Active	Open
Wetlands of the sub-humid tropics of the NT	PWCNT Peter Whitehead	To obtain a functional classification of the wetlands for management planning and obtain information on the distribution and abundance of waterbirds in the NT	Point data, field visits, aerial transects, map interpretation	Closed	Restricted
Feral animal survey - Alice Springs 1984	PWCNT Dave Berman	To estimate the number of feral horses and other large vertebrates in the Alice Springs area	Aerial transects running north and south 20 km apart at altitude 250 ft	Closed	Open
Feral animal survey - MacDonnell Ranges 1988	PWCNT Dave Berman	To estimate the number of feral horses and other large vertebrates and to monitor population changes since the 1984 survey	Feral animal population counts by aerial transects spaced 10 km apart	Closed	Open

Appendix 2 (cont'd)

Dataset	Custodian	Purpose	Nature	Status	Access
Flora - Finke Gorge National Park vegetation survey	PWCNT Brenda Pitts	To provide data for the conservation management of Finke Gorge National Park	Rare species locations, fire regime data, flora distribution and abundance, floristics, data on soils and soil erosion, landforms, geology and weeds	Active	Restricted
Flora - Nomenclature, distribution and conservation status	PWCNT Dave Albrecht	Store information on the nomenclature, distribution and reservation status of plants in the arid zone and Mitchell grass plains	Fields include family, native or introduced, name, Barlow region, bioregion, no. reserved and non-reserved occurrences etc. This database is a precursor to a larger database on the biology of the Southern Region	Active	Open
Flora - West MacDonnell Ranges vegetation survey	PWCNT Brenda Pitts	To provide data for conservation management in the West MacDonnell Ranges National Park	Rare species locations, fire regime data, flora distribution and abundance, floristics, data on soils and soil erosion, landforms, geology and weeds	Closed	Restricted
Palaeodrainage study dataset	PWCNT Geoff Foulkes	To determine whether certain flora and fauna species are associated with moisture and nutrient gradients	3 study sites (2 in Tanami Desert, 1 in Uluru), 3 transects per site with 5 quadrats per transect. Traps and photo centre points	Closed	Open
Weeds of the Southern Region	PWCNT Dave Albrecht	Provide information on the distribution, biology, etc of southern region weed species	Fields include life form, no. of localities, last collection, origin, dispersal type, extent of infestation, potential range, control methods, ecological impact, relationship with disturbance	Active	Open

Appendix 3

IBRA regions and nature reservation areas in the Northern Territory (–, missing data)

Bioregion		IBRA Code	Area (km²)	Restricted (R) or shared (S)	Area in NT (km²)	% in NT	Reserved area (km²)	Reservation status (% area)	Bias	No. of Protected Areas
Northern	Top End Coastal	TEC	68681	R	68681	100	10212	>10%	Moderate	29
	Pine-Creek Arnhem	PCA	51576	R	51576	100	13195	>10%	Low	14
	Central Arnhem	CA	36898	R	36898	100	0	0	–	0
Central	Daly Basin	DAB	20921	R	20921	100	393	1-5%	High	16
	Victoria Bonaparte	VB	72970	S	53882	74	6844	>10%	Moderate	9
	Ord-Victoria Plains	OVP	125177	S	70544	56	3597	5-10%	High	4
	Sturt Plateau	STU	99719	R	99719	100	56	<1%	High	1
	Gulf Fall and Uplands	GFU	118975	S	112595	95	80	<1%	High	1
	Gulf Plains	GUP	211584	S	834	4	0	0	–	0
	Gulf Coastal	GUC	27807	S	27687	99	51	<1%	High	1
	Mt Isa Inlier	MII	66586	S	164	3	0	0	–	0
	Mitchell Grass Downs	MGD	319788	S	92323	29	551	<1%	High	3
Southern	Tanami	TAN	316656	S	289747	92	1352	<1%	High	7
	Burt Plain	BRT	71809	R	71809	100	22	<1%	High	12
	Channel Country	CHC	305543	S	22806	8	0	0	–	0
	Great Sandy Desert	GSD	394599	S	100625	26	1521	1-5%	High	2
	MacDonnell Ranges	MAC	36986	R	36986	100	3736	>10%	Moderate	17
	Finke	FIN	75157	S	55705	74	37	<1%	High	5
	Central Ranges	CR	97061	S	25993	27	0	0	–	0
	Simpson-Strzelecki Dunefields	SSD	277876	S	105996	38	50	<1%	High	1
	Stony Plains	STP	181591	S	1707	9	0	0	–	0

Appendix 4

Summary description of landscape, wetland resources, uses, dominant threats and possible management responses in biogeographic region of the NT

The information in the tables that follow is derived from the main text which also lists reference sources and provides expanded facts and discussions. The Appendix is designed as a summary of the text and not as a stand-alone document. To some extent, however, it does represent a rudimentary inventory of NT wetlands with the emphasis on management issues. It is noted, with some emphasis, that the development of a comprehensive wetland inventory is one of the main strategies recommended in this report for enhancing the conservation and sustainable utilisation of wetlands and their resources. The nature of this inventory is open to discussion, but two key elements should be addressed:

1 a mechanism(s) to verify and update the information, and

2 a relational database format should be adopted.

Descriptions of the biogeographic regions are drawn from Thackway and Cresswell (1995). Figure 4 shows their distribution. Climate information was drawn from Lee and Neal (1984). Information on wetlands was partly drawn from Jaensch (1993, 1994).

Four biogeographical regions (Gulf Plains, Mt Isa Inlier, Channel Country and Stony Plains) of less than 10% land area each in the NT are not included.

Top End Coastal (TEC)

Dominant geology and other landscape features	• Arnhem Coast (ARC): Gently undulating plains and low plateaux on lateritised Cretaceous sandstones and siltstones; sandy red and yellow earths and siliceous sands; Darwin woollybutt/Darwin stringybark open forest with sorghum understorey • Darwin Coastal (DAC): Gently undulating plains on lateritised Cretaceous sandstones and siltstones; sandy and loamy red and yellow earths and siliceous sands; Darwin woollybutt/Darwin stringybark open forest with sorghum understorey, and flood plains on recent alluvium; vertosols, sedgeland and grassland • Tiwi-Cobourg (TIW): Gently sloping terrain on lateritised Cretaceous sandstones and siltstones; sandy and loamy red and yellow earths and siliceous sands; Darwin woollybutt/ Darwin stringybark/ Melville Island bloodwood open forest with sorghum
Climate	• Generally over 1 200 mm of distinctly summer rainfall. Rainfall on over 80 d yr^{-1}. Average annual potential evaporation approx 2 800 mm yr^{-1} • Relatively low variability and small range of temperatures. Average annual temperature approx. 27°C. Highest average maximum temperatures in November. No frost days per year • Winter and spring fire season
Wetland resource	• Wetlands relatively well known • Intertidal saltmarshes - Extensive areas along the coast, good examples are the Fog Bay System associated with the Finniss River, the estuary of the Daly-Reynolds and Boucaut Bay associated with the Blyth-Cadell Rivers. These are significant stop-over areas for migratory shorebirds • Mangrove-swamps - the Cobourg Peninsula (Minimini block) contains a good example of this wetland type, one of the largest discrete blocks of mangrove in the NT. Darwin Harbour contains another large discrete area of mangrove swamp probably the largest in the NT. These areas are significant as nurseries for marine fish and crustaceans • Freshwater lakes and swamps - Lake Finniss, the largest floodplain lake in the Top End is an internationally important site for Little Curlews. The Arafura Swamp is a good example of a wooded swamp, the largest in the NT and is significant as a Magpie Goose, saltwater crocodile and freshwater crocodile breeding area • Floodplains - Good examples of this wetland type are the South and East Alligator in Kakadu NP, Adelaide, Blyth-Cadell, Daly-Reynolds, Finniss, Mary, Moyle and the Murganella-Cooper. Major breeding areas for magpie geese, saltwater crocodile, herons and allies; major Dry season refuge areas for waterbirds (geese, ducks and herons); and significant migration stop-over for shorebirds
Wetland values	• Functions: groundwater recharge; groundwater discharge; nutrient retention; biomass export; recreation/tourism • Products: wildlife resources; fisheries; forage resources; agricultural resources; water supply • Attributes: biological diversity; uniqueness to cultural heritage, geomorphic diversity
Reservation status of wetlands	• Wetlands relatively well represented within conservation areas ie Kakadu National Park, Mary River Conservation Reserve, Cobourg National Park • Over 3/4 of area under Aboriginal jurisdiction with little nature reserve area
Major land uses	• Urbanisation (Darwin) • Pastoralism • Horticulture • Conservation areas (Kakadu NP, Gurig NP, Wildman River Conservation Area, Mary River Conservation Area and assorted smaller reserves) • Aboriginal land in the west, east and on Groote Eylandt and the Tiwi Islands • Mining

Top End Coastal (TEC) (cont'd)

Dominant condition of bioregion	• In areas closer to Darwin indigenous ecosystems present but coexisting with pastoral industries • In other areas (particularly Aboriginal lands) indigenous ecosystems dominant with no widespread degrading land use (however processes of disturbance present, ie feral animals, weeds, fire)
Dominant threats	• Conflicting land uses (highest pressure bioregion) • Overgrazing • Poor land management • Introduced pasture species • Changed fire regimes • Weeds (mimosa, water hyacinth, salvinia, paragrass, couch, candle bush, coffee bush, sida, hyptis) • Feral animals (pig, horse and buffalo) • Salinisation
Suggested management responses	• Development of integrated conservation plans • Assessment of reserve status and representativeness, eg Woinarski (1992) states that eastern Arnhem Land-Groote Eylandt have high priority for reserve establishment because of high general ecological values (ie biodiversity and endemism) • Mangrove extent and function need assessment and ecological interaction with surrounding landscape identified and quantified • Establishment of sustainable grazing practices and conservation covenants • Restrictions on the further spread of introduced pasture species, in particular ponded pastures • Establishment of riparian conservation corridors on major river systems • Encouragement and public awareness of the principles and practices of ecological sustainable development • Survey and experimental assessments of the effect of fire regimes on floodplain biota and functions • Restrictions on the importation of exotic fish for aquaria • Risk assessments of the effects of weeds and feral animals and means of controlling them on floodplains, including post-control rehabilitation of degraded areas • Implementation of means to survey, monitor and assess the extent and rate of salinisation and the likely success and broader ecological consequences of both 'soft' and 'hard' engineering approaches

Pine-Creek Arnhem (PCA)

Dominant geology and other landscape features	• Pine Creek (PCK): Hilly to rugged terrain on Proterozoic sandstones and siltstones; skeletal soils and shallow, silty profiles; Darwin boxwood and round-leaved bloodwood woodland with a sorghum understorey • Arnhem Plateau (ARP): Rugged dissected terrain and plateaux on Proterozoic sandstones; skeletal soils and rock outcrop; variable-barked bloodwood and Darwin woollybutt low open forest to woodland with spinifex understorey
Climate	• Generally between 1 000 – 1 200 mm of distinctly summer rainfall. Rainfall on over 60 d yr^{-1}. Average annual potential evaporation between 2 800–3 200 mm yr^{-1} • Moderate variability and range of temperatures. Average annual temperature approx. 27 °C. Highest average maximum temperatures in October. No frost days per year • Winter and spring fire season
Wetland resource	• Wetlands resource moderately known • Upper reaches of the coastal floodplains extend into this region in the north • The dissected plateau of Arnhem Land contains the headwaters of major coastal rivers and this region contains the middle reaches of those rivers • The Katherine River Gorge is a good example of a major, permanent river-pool system situated in a spectacular gorge; one of the largest gorges in the NT and one of the best known in tropical Australia. It is a major Dry season refuge for aquatic fauna, particularly fish, freshwater crocodiles and turtles
Wetland values	• Functions: groundwater recharge; groundwater discharge; nutrient retention; biomass export; recreation/tourism • Products: wildlife resources; fisheries; forage resources; agricultural resources; water supply • Attributes: biological diversity; uniqueness to cultural heritage, geomorphic diversity
Reservation status of wetlands	• Wetlands relatively well represented within conservation areas • Kakadu National Park (ie the bulk of the Kakadu plateau and lowlands) • Nitmiluk (Katherine Gorge) National Park
Major land uses	• Pastoralism • Agriculture • Mining • Conservation areas (bulk of Kakadu NP, Nitmiluk NP, McKinlay River Conservation Reserve, Arnhem Hwy Protected Area, eastern part of Litchfield NP, Manton Dam Recreation Area)
Dominant condition of bioregion	• In closer settled areas indigenous ecosystems present but coexisting with pastoral industries • In other areas (particularly Aboriginal lands and conservation areas) indigenous ecosystems dominant with no widespread degrading land use (however processes of disturbance present, ie feral animals, weeds, fire)
Dominant threats	• Overgrazing • Clearing • Weeds (rubber bush, bellyache bush, Noogoora burr, candle bush, sida species and hyptis) • Feral animals (pig, donkey, horse)
Suggested management responses	• Establishment of sustainable grazing practices and conservation covenants • Encouragement and public awareness of the principles and practices of ecological sustainable development • Establishment of riparian conservation corridors on major river systems • Restrictions on the further spread of introduced pasture species • Risk assessments of the effects of weeds and feral animals and means of controlling them on floodplains, including post-control rehabilitation of degraded areas

Central Arnhem (CA)

Dominant geology and other landscape features	• Gently sloping terrain and low hills on Cretaceous sandstones and siltstones and lateritised Tertiary material; yellow earthy sands and shallow stony sands • Darwin woollybutt and Darwin stringybark open forest to woodland with grass understorey
Climate	• Generally between 800–1 200 mm of distinctly summer rainfall. Rainfall on 60–80 d yr^{-1}. Average annual potential evaporation approx 2 800 mm yr^{-1} • Relatively low variability and small range of temperatures. Average annual temperature approx. 27 °C. Highest average maximum temperatures in November. No frost days per year • Winter and spring fire season
Wetland resource	• Wetlands poorly known • The large Arafura Swamp overlaps the northern boundary • A ghost gum/swamp bloodwood community associated with the Wilton River is found in the south • Short coastline with intertidal swamp marshes
Wetland values	• Functions: groundwater recharge; groundwater discharge; nutrient retention; biomass export; recreation/tourism • Products: wildlife resources; forage resources • Attributes: biological diversity; uniqueness to cultural heritage, geomorphic diversity
Reservation status of wetlands	• No wetlands in conservation areas
Major land uses	• Aboriginal land
Dominant condition of bioregion	• Indigenous ecosystems dominant with no widespread degrading land use (however processes of disturbance present, ie feral animals, weeds, fire)
Dominant threats	• Changed fire regimes • Weeds (lion's tail, bellyache bush, devil's claw, fierce thornapple) • Feral animals (buffalo, pig, donkey, horse)
Suggested management responses	• Inventory of wetlands • Survey and experimental assessments of the effect of fire regimes on wetland biota and functions • Assessment of reserve status and representativeness • Implementation of regional programs for the prevention and control of weeds and feral animals

Daly Basin (DAB)

Dominant geology and other landscape features	• Gently undulating plains and scattered low plateau remnants on Palaeozoic sandstones, siltstones and limestones • Neutral loamy and sandy red earths • Darwin stringybark and Darwin woollybutt open forest with perennial and annual grass understorey
Climate	• Approx 1 200 mm of distinctly summer rainfall. Rainfall on 70–80 d yr^{-1}. Average annual potential evaporation approx 2 800–3 200 mm yr^{-1} • Moderate variability and range of temperatures Average annual temperature approx. 28 °C. Highest average maximum temperatures in October/November. No frost days per year • Winter and spring fire season
Wetland resource	• Wetland resource poorly known • Katherine/Daly River Catchment. The Daly River is a good example of a permanent freshwater river occurring in low relief country. A major breeding and Dry season refuge for freshwater turtle, fishes and freshwater crocodile
Wetland values	• Functions: groundwater recharge; groundwater discharge; nutrient retention; biomass export; recreation/tourism • Products: wildlife resources; forage resources; agricultural resources; water supply • Attributes: biological diversity; uniqueness to cultural heritage, geomorphic diversity
Reservation status of wetlands	• Some conservation of wetland resource - small conservation areas along the Daly River catchment (Umbrawarra Gorge, Butterfly Gorge, Douglas Hotsprings, Oolloo Crossing, Douglas/Daly Esplanade) and the southern part of Litchfield NP
Major land uses	• Pastoralism • Urbanisation (Katherine) • Horticulture (Douglas/Daly) • Aboriginal land • Small conservation areas
Dominant condition of bioregion	• Indigenous ecosystems present but coexisting with pastoral industries
Dominant threats	• Clearing • Agricultural runoff • Weeds (bellyache bush, rubber bush, devil's claw, Noogoora burr, parkinsonia) • Feral animals (pig, donkey, horse)
Suggested management responses	• Inventory of wetland resource • Assessment of reserve status and representativeness • Development of integrated conservation plans especially to deal with the expanding horticultural and irrigated cropping industry which could lead to pollution from agricultural chemicals • Establishment of sustainable grazing practices and conservation covenants • Restrictions on the further spread of introduced pasture species • Establishment of riparian conservation corridors on major river systems • Encouragement and public awareness of the principles and practices of ecological sustainable development • Risk assessments of the effects of weeds and feral animals and means of controlling them

Victoria Bonaparte (VB)

Dominant geology and other landscape features	• Phanerozoic strata of the Bonaparte Basin in the northwestern part are mantled by Quartenary marine sediments supporting samphire - *Sporobolus* grasslands and mangal, and by red earth plains and black soil plains with an open savanna of high grasses • Plateaux and abrupt ranges of Proterozoic sandstone, known as the Victoria Plateau, occur in the south and east, and are partially mantled by skeletal sandy soils with low tree savannas and hummock grasslands • In south east limited areas of gently undulating terrain on a variety of sedimentary rocks supporting low snappy gum over hummock grasslands and also of gently sloping floodplains supporting *Melaleuca minutifolia* low woodland over annual sorghums
Climate	• Approx 800–1 000 mm of distinctly summer rainfall. Rainfall on approx 60 d yr^{-1}. Average annual potential evaporation approx 2 800 mm yr^{-1} • Relatively low variability and small range of temperatures. Average annual temperature approx. 28 °C. Highest average maximum temperatures in October/November. No frost days per year • Winter and spring fire season
Wetland resource	• Wetlands moderately well known • Coastline deeply indented by broad estuaries of the Keep and Victoria Rivers. Systems of channels and silt islands (to 10 km long) lie near the estuary mouths • Intertidal salt marshes (to 20 km wide) dissected by tidal channels , occur throughout • Several areas of riverine floodplain occur; smaller than those that occur in the Top End • Along the Baines River to its junction with the Victoria River are scattered freshwater swamps containing coolibah/gutta percha. This vegetation type also extends north along the Angalarri River
Wetland values	• Functions: groundwater recharge; groundwater discharge; nutrient retention; biomass export; recreation/tourism • Products: wildlife resources; forage resources; agricultural resources; water supply • Attributes: biological diversity; uniqueness to cultural heritage, geomorphic diversity
Reservation status of wetlands	• Conservation areas do not include major wetlands
Major land uses	• Pastoralism • Aboriginal land • Conservation area (Gregory NP, Keep River NP) • Potential expansion of horticulture on Keep River Floodplain from Ord River Scheme
Dominant condition of bioregion	• Indigenous ecosystems dominant with no widespread degrading land use (however processes of disturbance present, ie feral animals, weeds, fire)
Dominant threats	• Changed fire regimes • Feral animals (pig, donkey) • Weeds (Noogoora burr, castor oil plant, parkinsonia, coffee senna, devil's claw, bellyache bush)
Suggested management responses	• Inventory of wetlands • Assessment of reserve status and representativeness • Establishment of sustainable grazing practices and conservation covenants • Establishment of riparian conservation corridors on major river systems • Encouragement and public awareness of the principles and practices of ecological sustainable development • Survey and experimental assessments of the effect of fire regimes on wetland biota and functions • Risk assessments of the effects of weeds and feral animals and means of controlling them

Ord-Victoria Plains (OVP)

Dominant geology and other landscape features	• Level to gently undulating plains with scattered hills on Cambrian volcanics and Proterozoic sedimentary rocks; vertosols on plains and predominantly skeletal soils on hills; grassland with scattered bloodwoods and snappy gum with spinifex and annual grasses • The lithological mosaic has three main components: 1. Abrupt Proterozoic and Phanerozoic ranges and scattered hills mantled by shallow sand and supporting *Triodia* hummock grasslands with sparse low trees 2. Cambrian volcanic and limestones form extensive plains with short grass (*Enneapogon* spp) on dry calcareous soils and medium-height grassland communities (*Astrebla* and *Dicanthium*) on cracking clays. Riparian forests of river gums fringe drainage lines 3. In the south-west, Phanerozoic strata expressed as often lateritised upland sandplains with sparse trees. This component recurs as the Sturt Plateau Region in central Northern Territory
Climate	• Approx 600–800 mm of distinctly summer rainfall. Rainfall on 40–60 d yr^{-1}. Average annual potential evaporation approx 3 200–3 600 mm yr^{-1} • Moderate variability and range of temperatures. Average annual temperature approx. 27 °C. Highest average maximum temperatures in November. No frost days per year • Winter and spring fire season
Wetland resource	• Wetlands moderately known • In the southern area near the WA border Nongra Lake and the Birrindudu Floodplain (bluebush shrubland) on Sturt Creek that drains to the very important wetland of Lake Gregory in WA
Wetland values	• Functions: groundwater recharge; groundwater discharge; nutrient retention; biomass export; recreation/tourism • Products: wildlife resources; forage resources • Attributes: biological diversity; uniqueness to cultural heritage, geomorphic diversity
Reservation status of wetlands	• Little representation of wetlands within conservation areas
Major land uses	• Pastoralism • Aboriginal land • Portion of a conservation area (Gregory NP)
Dominant condition of bioregion	• Indigenous ecosystems present but coexisting with pastoral industries
Dominant threats	• Overgrazing • Feral animals (donkey, camel, pig) • Weeds (Noogoora burr, parkinsonia, devil's claw, dalbergia, khaki weed, downy thornapple, caltrop, bellyache bush, coffee senna, prickly acacia, hyptis, sida)
Suggested management responses	• Inventory of wetlands • Assessment of reserve status and representativeness • Establishment of sustainable grazing practices and conservation covenants • Restrictions on the further spread of introduced pasture species • Establishment of riparian conservation corridors on major river systems • Encouragement and public awareness of the principles and practices of ecological sustainable development • Risk assessments of the effects of weeds and feral animals and means of controlling them

Sturt Plateau (STU)

Dominant geology and other landscape features	• Gently undulating plains on lateritised Cretaceous sandstones • Neutral sandy red and yellow earths • Predominantly variable-barked bloodwood woodland with spinifex understorey
Climate	• Approx 600–800 1 200 mm of distinctly summer rainfall. Rainfall on 40–60 d yr^{-1}. Average annual potential evaporation approx 3 600–4 000 mm yr^{-1} • Moderate variability and range of temperatures. Average annual temperature approx. 26 °C. Highest average maximum temperatures in November. No frost days per year • Winter and spring fire season
Wetland resource	• Wetlands moderately known • Large area of coolibah/gutta percha community associated with the floodplains of Newcastle Creek in the southeast of the region • Coolibah community associated with floodplains of water courses in the north of the region • Mataranka Thermal Springs are a good example of tropical springs and associated permanent pools
Wetland values	• Functions: groundwater recharge; groundwater discharge; nutrient retention; biomass export; recreation/tourism • Products: wildlife resources; forage resources • Attributes: biological diversity; uniqueness to cultural heritage, geomorphic diversity
Reservation status of wetlands	• Poor reservation status of wetlands; one small conservation area (Elsey NP/Mataranka Hotsprings) in the north
Major land uses	• Pastoralism • Aboriginal land • Small conservation area
Dominant condition of bioregion	• Indigenous ecosystems present but coexisting with pastoral industries
Dominant threats	• Overgrazing • Feral animals (camel, donkey, horse) • Weeds (parkinsonia, bellyache bush, rubber bush, hyptis)
Suggested management responses	• Further inventory of wetlands • Assessment of reserve status and representativeness • Establishment of sustainable grazing practices and conservation covenants • Establishment of riparian conservation corridors on major river systems • Encouragement and public awareness of the principles and practices of ecological sustainable development • Risk assessments of the effects of weeds and feral animals and means of controlling them

Gulf Falls and Uplands (GFU)

Dominant geology and other landscape features	• Undulating terrain with scattered low, steep hills on Proterozoic and Palaeozoic sedimentary rocks, often overlain by lateritised Tertiary material • Skeletal soils and shallow sands • Darwin boxwood and variable-barked bloodwood woodland to low open woodland with spinifex understorey
Climate	• Approx 600–800 mm of distinctly summer rainfall. Rainfall on 40–50 d yr^{-1}. Average annual potential evaporation approx 3 200–3 600 mm yr^{-1} • Moderate variability and range of temperatures. Average annual temperature approx. 26 °C. Highest average maximum temperatures in November. No frost days per year • Winter and spring fire season
Wetland resource	• Wetlands poorly known • The dissected plateau (range) country is generally well drained and lacks basin-form wetlands (Jaensch 1994) • Ghost gum/swamp bloodwood community is associated with the Minerou River in the north of the region • Coolibah communities are associated with the upper reaches of the Roper River in the north and the McArthur River in the centre of the region
Wetland values	• Functions: groundwater recharge; groundwater discharge; nutrient retention; biomass export; recreation/tourism • Products: wildlife resources; forage resources • Attributes: biological diversity; uniqueness to cultural heritage, geomorphic diversity
Reservation status of wetlands	• Poor representation of wetlands within conservation areas; only part of a conservation area in the north (Elsey NP)
Major land uses	• Pastoralism predominates • Aboriginal land • Small conservation area
Dominant condition of bioregion	• Indigenous ecosystems present but coexisting with pastoral industries
Dominant threats	• Overgrazing • Feral animals (cane toad, pig) • Weeds (Noogoora burr, parkinsonia, caltrop, khaki weed, Mexican poppy, sida, hyptis)
Suggested management responses	• Inventory of wetlands • Assessment of reserve status and representativeness • Establishment of sustainable grazing practices and conservation covenants • Establishment of riparian conservation corridors on major river systems • Encouragement and public awareness of the principles and practices of ecological sustainable development • Risk assessments of the effects of weeds and feral animals and means of controlling them

Gulf Coastal (GUC)

Dominant geology and other landscape features	• Gently undulating plains with scattered rugged areas of Proterozoic sandstones and Tertiary sediments • Sandy red earths and shallow gravelly, sand soils • Darwin stringybark woodland with spinifex understorey
Climate	• Approx 800–1 000 mm of distinctly summer rainfall. Rainfall on 50–60 d yr^{-1}. Average annual potential evaporation approx 3 200 mm yr^{-1} • Relatively low variability and small range of temperatures. Average annual temperature approx. 27 °C. Highest average maximum temperatures in December. No frost days per year • Winter and spring fire season
Wetland resource	• Wetlands moderately well known • Long coastline (c. 375 km) generally straight with minor indentations at the estuaries of six rivers and numerous creeks • A delta with distributionary channels occurs at the mouth of the McArthur River. The Port McArthur Tidal Wetlands System is good example of coastal salt marshes and is associated with the largest area of intertidal mudflats in the south-west of the Gulf. It is a major stop-over site and overwintering area for migrating shorebirds • Lake Eames in the Port McArthur Tidal Wetlands System is the only sizeable, permanent freshwater lake in the south-west of the Gulf • Intertidal salt marshes up to several kilometres wide occur along most of this coast and beach ridges give way to broad saline flats (a few up to 10 km wide) immediately inland. The Limmen Bight Tidal Wetlands System is a good example of coastal salt marshes with a high volume of freshwater inflow. It is the second largest area of saline coastal flats in the NT and plays an important role as a stop-over area for shorebirds (especially godwits and knots) and one of the most important coastal sites in the NT in terms of shorebird numbers • Riverine freshwater floodplains are absent but some parts of the coastal plain are poorly drained and therefore support numerous swamps (Jaensch 1994)
Wetland values	• Functions: groundwater recharge; groundwater discharge; nutrient retention; biomass export; recreation/tourism • Products: wildlife resources; fisheries; forage resources; water supply • Attributes: biological diversity; uniqueness to cultural heritage, geomorphic diversity
Reservation status of wetlands	• No representation of wetlands within conservation areas though there are moves to declare a large conservation area around the Limmen Bight
Major land uses	• Largely pastoral leases • Aboriginal land • Mining
Dominant condition of bioregion	• Indigenous ecosystems present but coexisting with pastoral industries
Dominant threats	• Overgrazing • Feral animals (cane toad, pig) • Weeds (parkinsonia, Noogoora burr, Mexican poppy, hyptis, sida species)
Suggested management responses	• Inventory of wetlands • Assessment of reserve status and representativeness, eg Woinarski (1992) states that the Gulf hinterland has high priority for reserve establishment because of high ecological values • Establishment of sustainable grazing practices and conservation covenants • Establishment of riparian conservation corridors on major river systems • Encouragement and public awareness of the principles and practices of ecological sustainable development • Risk assessments of the effects of weeds and feral animals and means of controlling them

Mitchell Grass Downs (MGD)

Dominant geology and other landscape features	• Undulating downs on shales and limestones • Grey and brown cracking clays • *Astrebla* spp grasslands and Acacia low woodlands
Climate	• Approx. 500–600 mm of distinctly summer rainfall. Rainfall on less than 40 d yr^{-1}. Average annual potential evaporation approx 3 600–4 000 mm yr^{-1} • Moderate variability and range of temperatures. Average annual temperature approx. 25 °C. Highest average maximum temperatures in November. No frost days per year • Winter and spring fire season
Wetland resource	• Wetland resources moderately well known from preliminary surveys by Jaensch (1994) • Freshwater ponds and swamps are found on the extensive black cracking clay (blacksoil) plains of the Barkly Tableland. Blacksoil wetlands often have pronounced 'gilgai' hollows, typically 1 m wide and 0.3 m deep, covering much of the wetland bed. Lake Woods, Tarrabool Lake, Corella Lake, Lake Sylvester, Lake De Burgh, Playford River, Brunette Creek etc • Lake Sylvester and Lake Woods are good examples of seasonal freshwater lakes (Lake Wood mostly lacking perennial vegetation), at the end of inland-draining, tropical creek systems. At times they play a major role as migration stop-over areas for shorebirds and periodically as major breeding areas for waterbirds. They are two of the largest such lakes in the NT • Coolibah community associated with the floodplains of water courses in northern Barkly
Wetland values	• Functions: groundwater recharge; nutrient retention; biomass export; recreation/tourism • Products: wildlife resources; forage resources • Attributes: biological diversity; uniqueness to cultural heritage, geomorphic diversity
Reservation status of wetlands	• Poor representation of wetland areas within conservation reserves - three small conservation areas (Connells Lagoon Conservation Reserve, Junction Reserve (Management Agreement) and Longreach Waterhole Protected Area)
Major land uses	• Pastoralism • Aboriginal land • Small conservation areas
Dominant condition of bioregion	• Indigenous ecosystems present but coexisting with pastoral industries
Dominant threats	• Overgrazing especially of bluebush swamps • Shallow rivers across some properties are at risk from weeds (prickly acacia, parkinsonia, mesquite, barleria, bellyache bush, coffee bush, Noogoora burr, rubber bush) • Feral animals (minor threat as this is beyond most rabbits and the large herbivores are relatively easily controlled) • Impacts of Aboriginal and non-indigenous hunting on waterbirds unknown
Suggested management responses	• Further inventory of wetlands • Assessment of reserve status and representativeness • Establishment of sustainable grazing practices and conservation covenants • Encouragement and public awareness of the principles and practices of ecological sustainable development • Risk assessments of the effects of weeds and feral animals and means of controlling them

Tanaml (TAN)

Dominant geology and other landscape features	• Mainly red Quartenary sandplains overlying Permian and Proterozoic strata which are exposed locally as hills and ranges • Alluvial and lacustrine calcareous deposits occur throughout • Sandplains support mixed shrub steppes of *Hakea suberea*, desert bloodwoods, acacias and grevilleas over *Triodia pungens* hummock grasslands while wattle scrub over *T. pungens* hummock grass communities occur on the ranges • In the north alluvial and lacustrine calcareous deposits are associated with Sturt Creek drainage, and support *Crysopogon* and *Iseilema* short-grasslands often as savannas with river gum
Climate	• Monsoonal influences are apparent in the northern portion of this region. Approx 250–400 of summer rainfall. Rainfall on approx 30 d yr^{-1}. Average annual potential evaporation approx 4 400 mm yr^{-1} • High variability and range of temperatures. Average annual temperature approx 24–25 °C. Highest average maximum temperatures in December/January. Approx 50 frost d yr^{-1} • Spring fire season
Wetland resource	• Poorly known wetland resources • Seasonal/intermittent saline lakes eg Lake Buck • Lander River system probably highly significant • Freshwater lakes and swamps - Lake Surprise at the termination of the Lander River is a good example of an episodic lake in the termination floodplain of a desert creek system; normally the largest body of freshwater in the Tanami Desert and one of the few inland freshwater lakes of the NT that is in a pristine condition. It is periodically a major drought refuge area for waterbirds and fish. Also small freshwater lakes and swamps are found scattered throughout the blacksoil plains (that occur patchily in the northwest) and the dune landforms of the northern Tanami desert eg Wilson Creek, Hooker Creek and Winnecke Creek
Wetland values	• Functions: groundwater recharge; groundwater discharge; nutrient retention; biomass export; recreation/tourism • Products: wildlife resources; forage resources • Attributes: biological diversity; uniqueness to cultural heritage, geomorphic diversity
Reservation status of wetlands	• Poor representation of wetland resource in conservation areas
Major land uses	• Aboriginal land use predominates • Pastoralism - patchy distribution of livestock production on pastoral leases in the east • Proposed conservation area in the east (Davenport Murchison NP)
Dominant condition of bioregion	• Indigenous ecosystems dominant with no widespread degrading land use (however processes of disturbance present, ie feral animals, weeds, fire)
Dominant threats	• Feral animals (camel, donkey, horse, pigs) pose the greatest threat • Overgrazing where livestock production occurs • Weeds (Noogoora burr, parkinsonia, hyptis) • Impacts of Aboriginal and non-indigenous hunting on waterbirds unknown • Possible impacts of changed fire regimes
Suggested management responses	• Inventory of wetlands • Assessment of reserve status and representativeness, eg Woinarski (1992) states that the northern fringe of the Tanami Desert and the Tennant Creek area have very high priority for reserve establishment because of general ecological values • Establishment of sustainable grazing practices and conservation covenants • Encouragement and public awareness of the principles and practices of ecological sustainable development • Risk assessments of the effects of weeds and feral animals and means of controlling them • Assessment of impact of hunting on wildlife • Survey and experimental assessments of the effect of fire regimes on wetland biota and functions

Burt Plain (BRT)

Dominant geology and other landscape features	• Plains and low rocky ranges of Pre-Cambrian granites • Red earths • Mulga and other acacia woodlands
Climate	• Approx 200–250 mm of summer rainfall. Rainfall on 20–30 d yr^{-1}. Average annual potential evaporation approx 3 600–4 000 mm yr^{-1} • High variability and range of temperatures. Average annual temperature approx 22–23 °C. Highest average maximum temperatures in January. Approx 70 frost d yr^{-1} • Spring and summer fire season
Wetland resource	• Poorly known wetland resources • Seasonal/intermittent saline lakes along the axis of the Burt Plain eg Lake Bennett and Napperby Lake
Wetland values	• Functions: groundwater recharge; groundwater discharge; nutrient retention; biomass export; recreation/tourism • Products: wildlife resources; forage resources • Attributes: biological diversity; uniqueness to cultural heritage, geomorphic diversity
Reservation status of wetlands	• Poor representation of wetlands within conservation areas
Major land uses	• Largely pastoral leases • Aboriginal land • Conservation area in the east (Dulcie Ranges NP)
Dominant condition of bioregion	• Indigenous ecosystems present but coexisting with pastoral industries
Dominant threats	• Overgrazing • Changes in catchment hydrology on flat landscapes due to overgrazing • Weeds (parkinsonia, Noogoora burr, Bathurst burr)
Suggested management responses	• Inventory of wetlands • Assessment of reserve status and representativeness • Establishment of sustainable grazing practices and conservation covenants • Encouragement and public awareness of the principles and practices of ecological sustainable development • Risk assessments of the effects of weeds and feral animals and means of controlling them

Great Sandy Desert (GSD)

Dominant geology and other landscape features	• Mainly tree steppe grading to shrub steppe in south; comprising open hummock grassland of *Triodia pungens* and *Plectrachne schinzii* with scattered trees of *Owenia reticulata* and bloodwoods and shrubs of *Acacia* spp, *Grevillea wickhamii* and *G. refracta*, on Quarternary red longitudinal sand dune fields overlying Jurassic and Cretaceous sandstones of the Canning and Amadeus Basins • *Casuarina decaisneana* (desert oak) occurs in the far east of the region • Gently undulating lateritised uplands support shrub steppe such as *Acacia pachycarpa* shrublands over *Triodia pungens* hummock grass • Calcrete and evaporite surfaces are associated with occluded palaeo-drainage systems that traverse the desert; these include extensive salt lake chains with samphire low shrublands, and *Melaleuca glomerata-M. lasiandra* shrublands
Climate	• Approx 200–250 mm of summer rainfall. Rainfall on approx 20 d yr^{-1}. Average annual potential evaporation approx 3 600–4 000 mm yr^{-1} • High variability and large range of temperatures. Average annual temperature approx 22–24 °C. Highest average maximum temperatures in January. 50–80 frost d yr^{-1} • Spring and summer fire season
Wetland resource	• Poorly known wetland resources • Seasonal/intermittent saline lakes - Lake White, Lake Mackay, Lake MacDonald, Lake Neale, Lake Amadeus and Lake Lewis are part of a chain that extends almost to the Finke River. Lake Amadeus is the largest saline lake entirely within the NT. Mostly bare of plant formations, some fringed with low open-shrubland (samphire)
Wetland values	• Functions: groundwater recharge; groundwater discharge; nutrient retention; biomass export; recreation/tourism • Products: wildlife resources; forage resources; water supply • Attributes: biological diversity; uniqueness to cultural heritage, geomorphic diversity
Reservation status of wetlands	• Poor representation of wetland areas within conservation area
Major land uses	• Largely Aboriginal land • Conservation area in the southeastern portion (Uluru NP) • Mining access for gas
Dominant condition of bioregion	• Indigenous ecosystems dominant with no widespread degrading land use (however processes of disturbance present, ie feral animals, weeds, fire)
Dominant threats	• Feral animals (rabbit, camel) on salt lake margins pose the greatest threat • Impacts of Aboriginal hunting on waterbirds unknown • Weeds (buffel grass, couch) • Tourism could introduce weeds • Mining is well controlled but could introduce weeds
Suggested management responses	• Inventory of wetlands • Assessment of reserve status and representativeness • Establishment of sustainable grazing practices and conservation covenants • Restrictions on the further spread of introduced pasture species • Encouragement and public awareness of the principles and practices of ecological sustainable development • Implementation of regional plans for the prevention of weed incursions

Macdonnell Ranges (MAC)

Dominant geology and other landscape features	• High relief ranges and foothills covered with spinifex hummock grassland, sparse acacia shrublands and woodlands along watercourses
Climate	• Approx. 200 mm of summer rainfall. Rainfall on approx 20 d yr^{-1}. Average annual potential evaporation approx 3 600 mm yr^{-1} • High variability and large range of temperatures. Average annual temperature 21 °C. Highest average monthly temperatures in January. 50–100 frost d yr^{-1} • Spring and summer fire season
Wetland resource	Wetland resource relatively well known The streams of the George Gill Ranges are the largest group in the southern region and are relatively pristine. The conservation values of these streams are extremely high; they represent unique aquatic communities of both ecological and evolutionary importance in the arid zone Permanent gorge and river pools found in the West MacDonnell Ranges support a rich and abundant invertebrate fauna as well as 11 fish species
Wetland values	• Functions: groundwater recharge; groundwater discharge; nutrient retention; biomass export; recreation/tourism • Products: wildlife resources; forage resources; agricultural resources; water supply • Attributes: biological diversity; uniqueness to cultural heritage, geomorphic diversity
Reservation status of wetlands	• Important scenic and biodiversity resources relatively well represented in conservation areas • Majority of the important permanent water in gorges and river pools in the West MacDonnell Ranges are found within the West MacDonnell National Park • Headwaters of Finke River are contained within Finke Gorge NP • Important streams of the George Gill Range are contained within Watarrka NP (Kings Canyon)
Major land uses	• Highest pressure area of the region • Pastoralism most widespread • Urbanisation (Alice Springs) • Aboriginal land • Conservation areas (West MacDonnell NP, Finke Gorge NP, Watarrka NP and assorted conservation reserves and nature parks) • Recreation • Tourism
Dominant condition of bioregion	• Indigenous ecosystems present but coexisting with pastoral industries
Dominant threats	• Poor management of permanent waterholes • Area probably at most risk from changes in hydrology and sedimentation from grazing in catchments • Feral animals (camel, pig, horse, donkey) • Weeds (buffel grass, couch, Athel pine, rubber bush, Noogoora burr, Bathurst burr, Mexican poppy
Management Suggested management responses	• Development of integrated conservation plans, especially for small permanent waterholes that are at risk from pollution from tourist usage • Establishment of sustainable grazing practices and conservation covenants • Encouragement and public awareness of the principles and practices of ecological sustainable development • Restrictions on the further spread of introduced pasture species • Risk assessments of the effects of weeds and feral animals and means of controlling them

Finke (FIN)

Dominant geology and other landscape features	• Arid sandplains, dissected uplands and valleys formed from Pre-Cambrian volcanics • Red earths and shallow sands • Spinifex hummock grasslands and acacia shrublands
Climate	• Approx 150–200 mm of summer rainfall. Rainfall on approx 20 d yr^{-1}. Average annual potential evaporation approx 3 600–4 000 mm yr^{-1} • High variability and large range of temperatures. Average annual temperature 22 °C. Highest average monthly temperatures in January. 50–100 frost d yr^{-1} • Spring and summer fire season
Wetland resource	• Wetland resource relatively well known • Important waterholes (some permanent) and wetlands associated with major rivers (Finke, Hugh, Palmer). The gorges system at the headwater of the Finke River is a good example of permanent river pools; this system is a major drought refuge area for fishes in Central Australia • Ephemeral saline lakes (samphire) extending in a chain from Lake Amadeus almost to the Finke River. This Karinga Creek palaeodrainage system is a good example of groundwater discharge lakes, of varied hydrological character, in a desert environment, which also function as episodic lakes
Wetland values	• Functions: groundwater recharge; groundwater discharge; nutrient retention; biomass export; recreation/tourism • Products: wildlife resources; forage resources; water supply • Attributes: biological diversity; uniqueness to cultural heritage, geomorphic diversity
Reservation status of wetlands	• Poor representation of wetland resource in conservation area
Major land uses	• Pastoralism most extensive • Tourism in 4WD • Mining exploration (minor) • Mines upstream • Only very small conservation reserves (Henbury Meteorites and Chambers Pillar)
Dominant condition of bioregion	• Indigenous ecosystems present but coexisting with pastoral industries
Dominant threats	• Overgrazing • Feral animals (camel, pig, horse, donkey) • Weeds (Mexican poppy; athel pine, Mossman River grass) • Catchment disruption and change in sedimentation regimes • Wood use by tourists
Suggested management responses	• Inventory of wetlands • Assessment of reserve status and representativeness • Establishment of sustainable grazing practices and conservation covenants • Encouragement and public awareness of the principles and practices of ecological sustainable development • Restrictions on the further spread of introduced pasture species • Risk assessments of the effects of weeds and feral animals and means of controlling them on floodplains, including post-control rehabilitation of degraded areas

Central Ranges (CR)

Dominant geology and other landscape features	• High proportion of Proterozoic ranges and derived soil plains, interspersed with red Quarternary sandplains • Sandplains support low open woodlands of either desert oak or mulga over *Triodia basedowii* hummock grasslands • Low open woodlands of ironwood (*Acacia estrophiolata*) and corkwoods (*Hakea* spp) over tussock and hummock grasses often fringe ranges • Ranges support mixed wattle scrub or *Callitris glaucophylla* woodlands over hummock and tussock grasslands
Climate	• Arid (approx. 200 mm) of summer and winter rainfall. Rainfall on less than 20 d yr^{-1}. Average annual potential evaporation approx 3 600 mm yr^{-1} • High variability and large range of temperatures. Average annual temperature 21 °C. Highest average monthly temperatures in January. Approx 100 frost d yr^{-1} • Spring and summer fire season
Wetland resource	• Poorly known wetland resource (some recorded by early explorers such as Giles)
Wetland values	• Functions: nutrient retention; biomass export; recreation/tourism • Products: wildlife resources; forage resources • Attributes: biological diversity; uniqueness to cultural heritage, geomorphic diversity
Reservation status of wetlands	• No conservation areas
Major land uses	• Aboriginal land • Possibility of increasing levels of pasture production • Aboriginal hunting • Uncontrolled 4WD access during dry periods
Dominant condition of bioregion	• Indigenous ecosystems dominant with no widespread degrading land use (however processes of disturbance present ie feral animals, weeds, fire)
Dominant threats	• Feral animals (camel) • Impact of Aboriginal hunting on waterbirds unknown
Suggested management responses	• Inventory of wetlands • Assessment of reserve status and representativeness • Establishment of sustainable grazing practices and conservation covenants • Encouragement and public awareness of the principles and practices of ecological sustainable development • Risk assessments of the effects of weeds and feral animals and means of controlling them on floodplains, including post-control rehabilitation of degraded areas

Simpson-Strzelecki Dunefields (SSD)

Dominant geology and other landscape features	• Arid dunefields and sand plains with sparse shrubland and spinifex hummock grassland • Cane grass on deep sands along dune crests
Climate	• Approx 100 mm of summer rainfall. Rainfall on less than 20 d yr^{-1}. Average annual potential evaporation approx 4 000 mm yr^{-1} • High variability and large range of temperatures. Average annual temperature 22 °C. Highest average monthly temperatures in January. Approx 40–50 frost d yr^{-1} • Spring and summer fire season
Wetland resource	• Poorly known wetland resource • Important wetlands associated with major (rare) rainfall events in the catchments of rivers which flood out (coolibah communities) into the desert (eg Todd, Plenty, Hale and Field), and shallow wetlands in clayey interdunes (chenopod swamps) after intense local events
Wetland values	• Functions: groundwater recharge; groundwater discharge; nutrient retention; biomass export • Products: wildlife resources • Attributes: biological diversity; uniqueness to cultural heritage; geomorphic diversity
Wetland reservation status	• Poor representation of wetland resource in conservation areas ie no wetland conservation
Major land uses	• Aboriginal land • Unalienated crown land • Small conservation area (Mac Clark - *Acacia peuce*)
Dominant condition of bioregion	• Indigenous ecosystems dominant with no widespread degrading land use (however processes of disturbance present ie feral animals, weeds, fire)
Dominant threats	• Feral animals (rabbit and camel) • Weeds (cool season weeds)
Suggested management responses	• Inventory of wetlands • Assessment of reserve status and representativeness • Encouragement and public awareness of the principles and practices of ecological sustainable development • Risk assessments of the effects of weeds and feral animals and means of controlling them on floodplains, including post-control rehabilitation of degraded areas

Appendix 5

a) Major weed species in Northern Territory wetlands

Species	Common name	Bioregional occurrence	Comments
Acacia nilotica	prickly acacia	CA, GFU, MGD	spreading tree
Alternanthera pungens	khaki weed	OVP, GFU	
Anndna glabra	pond apple	TEC (limited distribution - Darwin gardens)	perennial tree
Argemone ochroleuca	Mexican poppy	BRT, MAC, FIN, MGD, GFU, GUC	annual herb
Barleria lupulina	barleria	PCA, DAB, MGD	perennial shrub
Barleria prioritis	barleria	PCA, DAB, MGD	perennial shrub
*Brachiaria mutica**	para grass	TEC	perennial grass
Calotropsis procera	rubber bush	PCA, DAB, VB, OVP, STU, MGD, BRT, MAC	shrub or small tree
Cenchrus ciliaris	buffel grass	TEC, OVP, STU, MGD, TAN, BRT, CHC, SSD, MAC, FIN, GSD, CR	perennial grass
Cenchrus echinatus	Mossman River grass	TEC, PCA, DAB, VB, GUC, GFU, TAN, BRT, MAC, FIN, GSD, CR	annual grass
Cynodon dactylon	couch	TEC, VB, MGD, TAN, BRT, MAC, FIN	perennial grass
Dalbergia sissoo	dalbergia	OVP	tree
Datura innoxia	downy thornapple	OVP	annual herb
Datura ferox	fierce thornapple	CA	annual herb
*Echinochloa polystachya**	Aleman grass	TEC (limited introductions at this stage)	perennial grass, major environmental weed in Queensland
Eichhornia crassipes	water hyacinth	TEC	free-floating aquatic
*Hymenachne amplexicaulis**	olive hymenachne	TEC	perennial grass, major environmental weed in Queensland
Hyptis suaveolens	hyptis	TEC, CA, PCA, VB, OVP, DAB, STU, TAN, MGD, GFU, GUC	annual shrub or woody herb
Jatropha gossypifolia	bellyache bush	TEC, OVP, STU, GFU, MGD	perennial shrub or small tree
Leonotis nepetifolia	lion's tail	TEC, CA	annual herb
*Leucaena leucocephala**	coffee bush	TEC	small tree
Martynia annua	devil's claw	VB, OVP, DAB, STU	annual herb
Mimosa pigra	mimosa	TEC	perennial shrub

Major weed species in Northern Territory wetlands (cont'd)

Species	Common name	Bioregional occurrence	Comments
Parkinsonia aculeata	parkinsonia	PCA, CA, VB, OVP, DAB, STU, GUC, GFU, MGD, CHC, TAN, BRT, MAC	small spreading tree
Prosopis glandulosa	mesquite	VB, STU, GFU, MGD	small tree
Ricinus communis	castor oil plant	VB, CR, BRT, MAC, FIN, SSD	tall branching shrub
Salvinia molesta	salvinia	TEC, VB, DAB, PCA	free-floating aquatic
Senna alata	candle bush	TEC, PCA	spreading shrub
Senna obtusifolia	sicklepod	TEC, PCA	annual or short-lived perennial
Senna occidentalis	coffee senna	TEC, PCA, DAB, BRT, MAC	annual or short-lived perennial
Sida acuta	spiny-head sida	TEC, VB, DAB, PCA, GUC, GFU	annual or short-lived perennial shrub
Sida cordifolia	flannel weed	TEC, DAB, VB, PCA	annual or short-lived perennial shrub
Sida rhombifolia	Paddy's lucerne	TEC, PCA, DAB, STU, GFU, CHC, BRT, MAC, FIN, CR	annual or short-lived perennial shrub
Tamarix aphylla	Athel pine	FIN	spreading tree
Thungergia grandiflora	green trumpet vine	TEC (cultivated in Darwin gardens)	perennial vine
Xanthium spinosum	Bathurst burr	MAC, FIN	annual herb
Xanthium strumarium	Noogoora burr	VB, OVP, TEC, PCA, DAB, GUC, GFU, MGD, STU, BRT, MAC	annual herb

* not regarded as a weed in all locations

b) Potential weeds not yet in the Northern Territory but present elsewhere in Australia

Species	Common name	Broad regional occurrence	Comments
Alternanthera philoxeroides	alligator weed	NSW	anchored floating aquatic
Cryptostegia grandiflora	rubber vine	north QLD	perennial/shrub scrambler
Egeria densa	dense water weed	QLD, NSW, VIC	submerged aquatic
Elodea canadensis	Canadian pond weed	NSW, VIC, TAS	submerged aquatic
Lagarosiphon major	lagarosiphon	VIC	submerged aquatic
Mimosa invisa	creeping sensitive plant	QLD	perennial scrambling vine

Source: Michael 1989

Appendix 6

Definitions of wetland products, functions and attributes

The following descriptions of wetland functions, products and attributes are primarily taken from the conservation and wise use concepts developed under the auspices of the Ramsar Convention for Internationally Important Wetlands (Dugan 1990, Davies & Claridge 1993, Davis 1994, CM Finlayson unpublished). The combination of wetland functions, products and attributes give the wetland ***benefits and values*** that make it important to society. This importance may be represented through both conservation and sustainable utilisation practices.

Functions performed by wetlands include the following: water storage; storm protection and flood mitigation; shoreline stabilisation and erosion control; groundwater recharge; groundwater discharge; water purification; retention of nutrients, sediments and pollutants; and stabilisation of local climatic conditions, particularly rainfall and temperature; water transport; and recreation and tourism. These functions are the result of the interactions between the biological, chemical and physical components of a wetland, such as soils, water, plants and animals.

Products generated by wetlands include the following: wildlife resources; fisheries; forest resources; forage resources; agricultural resources; and water supply. These products are generated by the interactions between the biological, chemical and physical components of a wetland.

Attributes of a wetland include the following: biological diversity; unique cultural and heritage features; and specific geomorphological features. These have value either because they induce certain uses or because they are valued themselves.

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